AN ANALYSIS OF TEACHERS' DISCOURSE WHEN TEACHING BASIC GENETICS CONCEPTS IN SOUTH AFRICAN CLASSROOMS

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ABSTRACT

South Africa has consistently ranked close to the bottom in international studies on the quality of mathematics and science education. This poor performance portrays a negative picture of the quality of teaching and learning science and mathematics in the country. Local reports such as the South African National Diagnostic Report on grade 12 performance attest to this as it shows that the quality of passes in life sciences at the matric level is low. As a result, fewer matriculants enrol for life sciences-related careers at higher institutions of learning. The overall quality of passes in life sciences could be aggravated by the poor performance of learners in genetics-related questions which make a substantial contribution to scores in the Life Sciences examination. Literature on the teaching and learning of genetics also points to difficulty with the teaching and learning of this topic, including the use of language by the teachers. This thesis reports on a case study in which I investigated the classroom Discourse of four life sciences teachers while teaching basic genetics to grade 12 learners. The study aimed to characterise the teachers' Discourse during the teaching of basic genetics. In this study, my conception of Discourse was influenced by Gee's Theory of Discourse which makes a distinction between Discourse with an upper-case 'D' denoting language and other factors associated with it and discourse with a lower-case 'd' as referring to language. Therefore, in this study, the teachers' Discourse 'D' was conceptualised in terms of language 'd' (the language of science) and context which entailed Discourse strategies, interaction patterns, teacher Discourse moves, and multimodal representations.

This study drew on literature and research from the fields of Discourse analysis, language, teacher talk, science teaching, and classroom Discourse to develop a complex picture of the classroom. A case study was conducted in three high schools in Johannesburg, South Africa. Data was collected from four teachers each of whom was observed three times, and video recorded while teaching basic genetics concepts to grade 12 learners. A follow-up interview was conducted with each teacher. These post-observation interviews together with field notes were added for data triangulation purposes. The interviews helped me to access teachers' rationale for taking certain actions during the observed lessons. Moreover, the interviews enhanced the trustworthiness of my analysis. The lesson observation transcripts were analysed using Lemke's Thematic Analysis merged with Mortimer and Scott's Communicative Approaches and Discourse patterns.

This study unveiled two major types of Discourse of teachers who followed an examination based approach and teachers whose Discourse followed a conceptual approach. This led to the development of a Discourse Teaching Strategy Model which portrays teachers as being either conceptually or assessment focused. My Discourse Teaching Strategy Model shows that amongst other characteristics, conceptually focused teachers used higher-order questions to build conceptual understanding and logical exposition for consolidation. Further, the model shows that logical exposition was sometimes replaced by selective summary where the teachers justified the curriculum. Teachers adopting a conceptual focused strategy used controlling pacing and marking importance as pedagogical measures and admonition for maintaining discipline.

This study contributes to the effective teaching of genetics by offering the Discourse Teaching Strategy Model as a model to guide thinking about the planning and development of science teaching as well as a tool for reflection upon one's teaching strategies. Thus, this model can be used to expand self-development or in-service development especially if one is to teach for

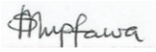
conceptual understanding. Researchers can use the model as an analytical tool for identifying a particular teacher's Discourse practices.

Keywords

Teachers' Discourse; Language; Genetics; Life Sciences; South Africa; Classrooms

DECLARATION

I declare that this thesis is my own unaided work. It is being submitted for the degree of Doctor of Philosophy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.



Shungu Mupfawa
23rd day of July in the year 2024

To my husband Tendai Mupfawa my greatest supporter and pillar of strength.

To my daughters Nyasha Melissa, and Nicole Ropafadzo and son Tendai Junior who were my study mates and remain my greatest cheerleaders

To my siblings Tarisai, the late Sunungukai, Blessing K, Tatenda, and Tanaka who are my supporters.

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PRESENTATIONS EMANATING FROM THIS RESEARCH

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- Mupfawa, S., Rollnick, M., Padayachee, K., Buma, A. (2022). An analysis of teachers' classroom discourse in basic genetics. In K. R. Langenhoven & C. H. Stevenson-Milln, *Book of Proceedings of the 30th Annual Conference of the Southern African Association for Research in Mathematics, Science and Technology Education*. Cape Town: SAARMSTE.

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LIST OF ABBREVIATIONS

A

ADM: admonition sequences

ATP: Annual Teaching Plan

B

BF: being funny

CAPS: Curriculum Assessment Policy Statement

CM: creating mysteries.

CP: controlling pacing

E

ESERA: European Science Education Research Association

ESL: English as a Second Language

ETD: external text dialogue

F

F/B: foregrounding and backgrounding

G

G1: Gap phase 1

G2: Gap phase 2

GDE: Gauteng Department of Education

GP: getting personal

GR: gesture representations

I

I-R-E: initiation-response-evaluation

I-R-P-R-F: initiation-response-prompt-response-feedback

IA: Interactive-Authoritative

ID: Interactive-Dialogic

IL: interrupting learners

INT: interview

J

JET: joint external text thematics

JLT: joint learner thematics

JT: joint teacher thematics

L

L1: First Language

L2: Second Language,

LO1: Lesson Observation 1

LO2: Lesson Observation 2

LO3: Lesson Observation 3

LOG EXP: logical exposition

LT: Learner thematics

M

M: multiplication phase

MI: marking importance

MNO/N: marking new/old information

N

NARR: narrative

NIA: Non-interactive Authoritative

NID: Non-interactive Dialogic

NOS: Nature of Science

NSC: National Senior Certificate

P

PMA: Post Graduate Merit Award

R

RD: Reducing difficulty

R: Researcher

S

S: synthesis phase

SAARMSTE: Southern African Association for Research in Mathematics, Science and Technology Education

SB: signalling boundaries

SEL SUM: selective summary

SFL: Systemic Functional Linguistics

TET: teacher external text thematics

TQS: teacher question series

TT: teacher thematics

VER: verbal representations

VIR: visual representations

CHAPTER 1: INTRODUCTION TO THE STUDY

1.0 Introduction

This introductory chapter presents an overview of the study, the rationale behind conducting it, the purpose and objectives, the researcher's positionality, and the thesis outline.

1.1 Background and statement of the problem

Genetics is the scientific study of heredity and variation in living things (Campbell et al., 2018). In simple terms, genetics shows us how individual behaviour and features are passed on from one generation to the next. Many popular scientific and technological advances are associated with genetics, for instance, the human genome project, genetically modified organisms, gene therapy, cloning of organisms, and the background of different illnesses such as Ebola (Altunoğlu & Şeker, 2015). However, genetics is perceived as one of the most difficult topics to teach and learn in biology (DBE, 2021b; Fauzi & Mitalistiani, 2018). What compounds this matter is that teachers are also identified as contributing to poor performance as they are said to be lacking confidence in teaching genetics (DBE, 2021b; Ndayambaje et al., 2021). Among other factors, language (discussed later in this section) has been identified as a key factor contributing to this poor performance (Maremane et al., 2022; Prinsloo et al., 2018). However, in my study, I did not consider issues of multilingualism or monolingualism instead my focus was on the language of science and Discourse of instruction. Thus, the focus of this study was teachers' use of the language of science while teaching basic genetics to grade 12 learners in their classrooms.

The importance of the phenomenon of genetics is also recognized in the South African Life Sciences Curriculum Statement (CAPS) which is a high-stakes curriculum. Much emphasis is placed on the topic of genetics which constitutes about 16% of the grade 12 life sciences examination (DBE, 2011). In particular, the genetics topic constitutes about 32% (48 marks) of paper 2. As well as being important, genetics is considered to be one of the most difficult topics to teach or learn and is characterized by poor learner performance in the grade 12 examination (DBE, 2021b). The importance of genetics in society coupled with poor learners' performance in genetics at matric motivated me to focus on the topic of genetics in this study. A better understanding of genetics could potentially result in a better understanding of another problematic topic, viz, evolution, which is linked to it (Altunoğlu & Şeker, 2015). This may, in the long run, improve the learners' performance in the two topics recorded by the National Diagnostic Report as the most difficult (DBE, 2021b: DBE 2023b). Genetics together with evolution constitute 102 out of 150 marks of paper 2 which is about 68% of the whole paper and 34% of the subject overall (DBE, 2021a). Hence, if teachers teach genetics well, learners may perform better in the examination since it underpins certain parts of the topic of evolution. Thus, an improvement in learners' performance in genetics may result in an improvement in the number of learners achieving quality passes at matric. I hope that this will result in more high school graduates enrolling in life sciences-related careers at institutions of higher learning, eventually reducing the shortage of skilled science personnel in South Africa.

South Africa has consistently ranked last or close to the bottom when it comes to worldwide studies on the quality of mathematics and science (Mullis et al., 2020). This performance portrays a negative picture of the quality of learners produced by South African teachers in these subjects. Even the annual South African National Diagnostic Report on grade 12 performance attests to this as it argues that the quality of passes in life sciences at matric is low (DBE, 2023b). It has been shown that less than 50 % of the students who sit for life sciences examinations achieve passes with 50% and above (DBE, 2023b) (see Table 1.1).

Table 1.1: Life Sciences Performance Trends

Year	Number wrote	% achived at 50% and above (estimated value)
2019	301 037	29.9
2020	319 228	28.9
2021	384 216	33.5
2022	399 007	30.4
2023	379 024	32.5

Adapted from National Diagnostic Report (DBE, 2023b, pp. 176-177)

These poor-quality passes in life sciences could be due to the poor performance by learners in genetics questions (DBE, 2021b). It is interesting to note that the pass achieved during the years of the COVID-19 pandemic remained mostly like other years although it was well-known that teaching and learning at schools was severely impacted. This status quo was maintained because a section referred to as 'Human Impact' was removed from the life sciences curriculum. This meant that learners had less content to deal with than in the pre-COVID-19 years. According to DBE (2021b), the following were some of the challenges identified in

Paper 2 of the 2021 life sciences examination regarding the actual questions on the genetics topic. Learners could not identify similar characteristics of homologous chromosomes because they did not understand the processes of *meiosis*, *crossing over*, *gamete formation*, *fertilisation*, and the *loci* of *genes*. In addition, learners had challenges with identifying differences between male and female karyotypes and there were also challenges with notations to use for different types of inheritance, for instance, $X^H X^H$ for sex-linked inheritance. Problems with the interpretation of *pedigree diagrams* and definitions were also identified for instance *gene mutation*.

Many teacher factors have been identified as contributing towards poor learners' performance in science for instance; negative attitude towards certain topics, the language of instruction, low quality in subject knowledge, teachers' instruction, teachers' qualifications, teacher absenteeism, teacher motivation (Maremane et al., 2022). Below I discuss the language of instruction (discourse with a lowercase 'd') used by teachers since it is directly related to my study.

Although there are many teacher factors influencing low performance in science (Prinsloo et al., 2018), the language used by teachers (the language of instruction) which is usually not the learners' home language or first language (L1) is notable (Msimanga et al., 2017; Pun et al., 2023). According to Shin et al. (2020), L1 refers to the first language that is used by learners at home whilst L2 is the medium of instruction, usually English, which may not be used by learners at home. Thus, learners whose mother tongue is any language other than English are referred to as English Second Language (ESL) learners (Prinsloo et al., 2018). In South African schools, English is identified as; home language, first additional language and second additional language (DBE, 2011). However, in my study, all learners whose mother tongue is any language other than English, were referred to as English second language (ESL) learners as they are referred to by Le Roux et al. (2017).

The use of English in the classroom by science teachers becomes a challenge to ESL learners who may not be proficient in it. The learning difficulties that learners encounter in mathematics and science are considered to be deeply rooted in learners with lower levels of proficiency in the language of instruction (Mohamed, 2015). This has been a common argument flowing through the following studies conducted locally (Mavuru & Ramnarain, 2020; Motloung et al., 2021; Msimanga, 2021). Nonetheless, the language associated with science has been identified as unfamiliar to all learners (Lemmi et al., 2019) because it is not common on playgrounds. This may imply that the language used in the science classrooms is difficult for all learners, including English first language speakers. Owing to the discussion above, the focus of my study was not on the language of instruction but on the language of science. In particular, it was on the teachers' use of the language of science in their contexts while teaching basic genetics which Gee (2017) refers to as Discourse with uppercase 'D'. In other words, this study examined the teachers' Discourse during the teaching of basic genetics to grade 12 learners.

1.2 Rationale for the study

Language competency is a basic requirement for science education as it is used for learning and teaching science, building understanding, and communicating science to other people so that they can make informed decisions and actions (Adams et al., 2015). Basic scientific topics such as genetics are communicated through written and spoken language (Thörne & Gericke, 2014a). This points us to the importance of language in genetics education.

Like other areas of science, language in biology is multi-modal implying that it can be verbal or written discourse, mathematical equations, or graphical representations (Kelly, 2014). In addition, while specialized terminology abounds in most scientific fields (Liu & Lei, 2019), the terms themselves are not the main problem. Rather, the way terms relate to each other is what matters (Thörne & Gericke, 2014a). Halliday and Martin (1993) argue that the specific characteristic of the science language is determined by the interaction between technical terms and other words, which they refer to as lexicogrammar. Lexicogrammar as a term was coined by the father of systemic functional linguistics, Michael Halliday (Ahmed, 2013). Lexicogrammar is a stratum of linguistic structure where vocabulary (lexis) and grammar (syntax) are combined into one entity (Schleppegrell & Oteíza, 2023). At this level, words and grammatical structures cease to be independent but rather become dependent on one another. This implies that terms cannot be defined in isolation from the words combined with them. It is this lexicogrammar that could be contributing significantly to the difficulties that learners encounter with science. Literature has further noted that teachers play a pivotal role in assisting learners to learn the language of science including its unique terms as well as its way of talking (Mortimer & Scott, 2003). Furthermore, teachers have been identified as the major source of information for their learners during the learning process (Thörne & Gericke, 2014a). This teacher factor prompted me to explore how the teachers use the science language during the teaching of basic genetics in their classrooms. Particularly, my intention was to characterise the teachers' Discourse (science language use in context) during the teaching of basic genetics to grade 12 learners.

In this study, l sought to investigate the teachers' Discourse using Discourse analysis as a lens. Discourse analysis is the study of what we humans do with language and how we do it (Gee, 2018). To conduct a Discourse analysis, I needed to be clear about what I meant by language. Linguists consider language to be the natural language, meaning the languages acquired by humans as their first. However, in this study, I used language to refer to what Gee (2018) refers to as Academic Social Language which is the special language used by experts or specialists in their academic contexts. Thus, a science classroom is an academic context where a special language is used, which is science language.

In this study, I investigated the teacher's Discourse which entails teachers' use of the science language in their contexts. In particular, I examined how the teachers developed genetics concepts in terms of the types of thematics that they constructed, the thematic items (science terms), and the semantic relations (thematic patterns) constructed using the identified thematic items. Types of thematics constructed could be joint thematics, teacher thematics or learner thematics depending on who constructed them. Joint thematics are constructed by the teacher together with learners while teacher thematics are constructed by teachers on their own and learner thematics are constructed by learners on their own. Examples of thematic items that were investigated in this study in terms of how they were used to construct semantic relations are *haploid, diploid, and mitosis.* Most of these words have been identified as problematic in literature (Machová & Ehler, 2023). In addition, research has shown that learners fail to make connections between some of these words that are related to each other (Thörne & Gericke, 2014a). Hence, this study sought to establish how teachers connect these words as they construct semantic relations which then result in thematic patterns when combined.

Several studies have been conducted on teacher talk in science classrooms (Mercer & Dawes, 2014; Ødegaard et al., 2016; Seah & Silver, 2020; Jing & Jing, 2018). While the studies recognize the importance of teachers' language in science classrooms, very few have analysed the teachers' language in action concerning genetics with the possible exception of Livni-Alcasid et al. (2018) Haskel-Ittah and Yarden (2018) and Puig et al. (2017). Most research conducted in genetics education has been on difficulties encountered during learning and teaching genetics, for example, Thörne and Gericke (2014a) and Kılıç et al. (2016). The few studies that focus on teachers' language concerning genetics include Livni-Alcasid et al. (2018) who analysed eight textbooks from three countries worldwide in terms of the symbol system they use for *alleles* and justifications provided for changes in the symbol system. In addition, Puig et al. (2017) examined how modelling and argumentation interact and connect the worlds of theories and models, objects and events as well as representations. Furthermore, Reinagel and Bray Speth (2016) engaged students in building conceptual models to explain how genes determine phenotypes.

I have noted that the studies discussed above have been conducted abroad, but not a single one has been conducted locally in South Africa. Furthermore, I have not come across a study that focuses on teachers' Discourse when teaching genetics, for this reason, I felt the study was justified. This study contributed to the effective teaching of genetics by providing a teaching model which I refer to as The Discourse Teaching Strategy Model. This model can be used by teachers as a tool for planning and reflection purposes: to plan for the appropriate combinations of strategies depending on whether they are interested in developing conceptual understanding with their learners or covering the curriculum for tests and examinations. Overall, this model can be used to expand self-development or in-service development especially if one is to teach for conceptual understanding.

Gee's theory of D/discourse was used as a tool for analysing the teachers' Discourse. Science is described as a subject that influences our everyday activities and is vital to both individuals and nations to meet global economic requirements (Coccia, 2019). Classroom Discourse refers to the conversation taking place in the classroom between teachers and learners, which includes verbal and non-verbal exchanges (Al-Smadi & Ab Rashid, 2017). In my study, science refered to life sciences, physical science, or mathematics. Therefore, in this study 'science classroom Discourse' referred to the conversations taking place in a life sciences classroom while Teachers' Discourse referred to the teachers' use of science language in their contexts.

As a life sciences teacher, my interest in teachers' use of language in life sciences classrooms was inspired by the enormous amount of terminology and concepts that both teachers and learners have to deal with for learners to perform well in the subject. This interest continued to grow as I became more experienced in the profession and deepened further in the year 2016 when I conducted a study to investigate the teachers' use of language in South African life sciences classrooms during my Masters' studies as I learned more about language. In the current study, I sought to explore the matter further from a different perspective to get a deeper understanding of the issues around language and genetics education. This might be fruitful in developing teachers into more effective teachers who will subsequently produce high school graduates who achieve high-quality grades in grade 12 in life sciences.

1.3 Linguistic Context

This study took place in South Africa where there are about 56 million people of various origins, cultures, religions, and languages (Lehohla, 2016). South Africa is a multilingual country with twelve official languages which are Sepedi, Sesotho, Setswana, siSwati, Tshivenda, Xitsonga, Afrikaans, English, isiNdebele, isiXhosa, isiZulu and sign language (Stoop, 2017). Out of the twelve languages, the most commonly spoken first languages are isiZulu, isiXhosa, and Afrikaans, though English which is rated the fourth South African Second Language is considered to be the language of commerce and science (Lehohla, 2016).

In South Africa every child has a right to receive education in any one of the official languages though in practice the medium of instruction is generally either English or Afrikaans (Stein, 2017). Of the two languages of instruction, English has become the dominant language, preferred by parents because it is perceived as a means for accessing social commodities, tertiary education, jobs that are fulfilling, power and influential positions in society (Mavuru & Ramnarain, 2020). This has been the order of the day even though English is an additional language for most South African learners and teachers alike.

For most learners in South African schools, English is a second or even a third language (Msimanga et al., 2017). Thus, gaining a level of proficiency in the language of instruction is considered to be a necessary initial step for learning. This is because learning is only possible when students are learning in the language in which they are proficient, (Mavuru & Ramnarain, 2020). As a result, it is assumed by many, including teachers that when English second language learners have attained proficiency in the language of instruction, learning can take place smoothly (Lin & Lin, 2016). It may be true that learners whose first language is not English may require more support to develop their English language skills but the language of science can be foreign and puzzling to all learners including those learners who are English first language learners (Mavuru & Ramnarain, 2020). This means that the language of science used in science classrooms is different from everyday English (Huerta et al., 2016) and is consequently difficult for all learners regardless of linguistic background (Mavuru & Ramnarain, 2020). The unfamiliar nature of the language of science is one of the factors contributing to the low performance in science in South Africa. Therefore, this study focused on the teachers' Discourse which is the teachers' use of the language of science when teaching basic genetics concepts in South African classrooms.

1.4 Purpose and objectives of the study

The purpose of my study was to explore the teachers' Discourse when teaching basic genetics concepts in South African classrooms using Discourse analysis as the lens. Since this study was underpinned by Gee's Theory of D/discourse it probed the teachers' actions, interactions, values, beliefs, and objects, tools, technologies, and environments that are associated with language-in-use (Gee, 2017) within a science classroom Discourse. In particular, I examined the teachers' Discourse in terms of the development of genetics concepts, forms of interaction patterns, teacher Discourse moves and Discourse strategies employed by teachers during the teaching of basic genetics to grade 12 learners.

1.4.1 Main research question

This study was guided by the following main research question:

What characterises the teacher's Discourse during the teaching of genetics in South African classrooms?

1.4.2 Sub-research questions

This study sought to address the following sub-research questions:

1. *How do teachers develop genetics concepts during the teaching of basic genetics to grade 12 learners?*
2. *What forms of interaction patterns and teacher Discourse moves are evident during the teaching of basic genetics to grade 12 learners?*
3. *What kinds of emergent teacher Discourse strategies can be extracted from teaching basic genetics to grade 12 learners?*

1.5 Conceptual Framework and Research Methods

This study was informed by Gee's theory of Discourse which makes a distinction between Discourse with a big 'D' denoting language and other factors associated with it and discourse with a lower-case 'd' as referring to language (Gee, 1996). Refer to section 2.4.1 in Chapter 2 for a more detailed account of the big 'D' and the small 'd'. Considering the South African linguistic context consisting of twelve official languages, and the fact that science has its language, I used discourse with a lower-case 'd' to represent language such as the different languages (language of science included) used in South African life sciences classrooms. However, it was not my intention to explore language in terms of the official languages but language in terms of science language. This study sought to explore the teachers' Discourse by examining how teachers use the language of science as they develop genetics concepts as stated by my first sub-research question. In terms of Discourse with a big 'D', I explored other factors associated with the language of science by analysing the patterns of interaction and teacher Discourse moves as stated in my second sub-research question. In addition, the teacher Discourse strategies stated in my third sub-research question were explored as factors associated with the language of science.

To conduct this research study, I adopted an interpretive research paradigm where I used a qualitative case study approach to collect, analyse and present data. In particular, I used video-recorded classroom observations, (field notes included) and audio-recorded post-classroom interviews to collect data for addressing my three sub-research questions. The data was collected from a research sample which was purposively selected consisting of four life sciences teachers (from three schools) as they taught basic genetics to grade 12 learners. To analyse the collected data, I used an analytical framework that merged Lemke's Thematic analysis (Lemke, 1990) and Mortimer and Scott's Communicative Approaches and Patterns of Discourse (Mortimer & Scott, 2003). More details about my research design and methodology are provided in Chapters 3 and 4. Next, I present my positionality as a researcher.

1.6 The Researcher Positionality

Positionality represents a space in which objectivism and subjectivism meet (Bourke, 2014). This means that we cannot be purely objective since we cannot truly divorce ourselves from subjectivity. Thus, as we attempt to be objective when conducting research, we must always be conscious of our subjectivities. As a naturalistic researcher (conducting research in situations where people usually interact) I need to acknowledge who I am as an individual and a member of different social groups. I was born in Zimbabwe where I did primary, secondary, and part of my tertiary education. In particular, I obtained a Diploma in Education from the University of Zimbabwe and my first degree from Zimbabwe Open University. I taught biology, physical science, and general science in Zimbabwe for nine years and then moved to South Africa in 2009 due to economic hardships.

In South Africa, I taught for a few years and did my Honours' degree after which I studied for my Masters' degree at the University of the Witwatersrand. All my education from primary school to where I am right now was conducted in my second language which is English. Thus, l have always been an English second language student throughout my academic career. Hence, if I were in Zimbabwe, I would occasionally use my mother tongue to clarify some science concepts considering that most learners there are English second language learners. I have been teaching life sciences and natural sciences for the past fifteen years at a Johannesburg high school in Gauteng province. I consider myself to be a successful life sciences teacher because l have a large cohort of learners who passed ordinary and advanced levels in Zimbabwe and Matric here in South Africa.

As a life sciences teacher, I believe that my duty is to assist my learners to become lifelong learners. To accomplish this, I engage in inquiry learning because I believe that the role of a teacher is not to provide learners with information and answers but to facilitate learning through the provision of resources and opportunities to learn. This approach encourages learners to think deeply about scientific ideas and motivates them to research more on their own. Interest and motivation are vital elements of inquiry learning, which I believe foster lifelong learning in learners. Thus, as a life sciences teacher, I am aware of the fact that learners may be interested in topics that are relevant to current events or their own experiences. For instance, when dealing with the topic of *biotechnology*, I break it down into sub-topics such as *genetic engineering*, *recombinant DNA technology*, and the *development of genetically modified organisms* and allow my learners to choose sub-topics of their interest. I allow them to choose because I believe that lifelong learning requires interest that stems from the learners' curiosity. Hence, choosing allows them to feel like they are in control of their lives and learning. In a way, this helps me to reduce conflict between us. As they work on their sub-topics, I allow them to use technology (cell phones and the internet) because I believe it serves as groundwork for learners' active construction of knowledge. I also understand that my learners are fully immersed in the technology world.

Apart from inquiry learning, I offer my learners differentiated instruction and employ strategies that appeal to different learning styles. Furthermore, I understand the relationship between teaching and assessment. I assess my learners to see what aspects of my teaching are going well and the ones that need improvement. I also use assessment results to improve my teaching and the overall outcomes of my learners.

1.7 Thesis Outline

In this chapter, which is my **chapter 1**, I describe the background of the problem that motivated me to embark on this study based on my observations as an experienced life sciences teacher. I have outlined the purpose of my study which was to analyse the teachers' Discourse during their teaching of basic genetics to grade 12 learners in South African classrooms. I intended to contribute to the knowledge base for teaching genetics to grade 12 learners to improve their overall quality of passes. In **Chapter 2**, I discuss various bodies of literature that are pertinent to my study. The bodies of literature formed a theoretical model from which I drew to conduct my study successfully. I outline my research methods and design in **Chapter 3**. In **Chapter 4**, I present a broad overview of the data processing and analysis procedures engaged in this study. In particular, I discuss the details of the sources of data used in this study, preparation of data for transcription, and preparation of data for entry into ATLAS.ti software and the analysis process. In this chapter, issues of credibility, trustworthiness and ethics are duly considered. In **Chapter 5** which is my first findings chapter, I illustrate, through the creation and identification of thematics, how teachers developed genetics concepts during the teaching of basic genetics to grade 12 learners. I do this by focusing on the thematic items used, how they were used to build semantic relations and subsequently the construction of thematic patterns. In **Chapter 6**, I demonstrate the patterns of interaction that were evident in terms of communicative approach, patterns of Discourse, and teacher Discourse moves. In particular, I focus on how teachers directed their science talk during the teaching of genetics concepts using one or more communicative approaches through a variety of teacher Discourse moves. In **Chapter 7**, I analyse the Discourse strategies that the teachers used to negotiate meaning-making of genetics concepts with their learners and generate a new teaching Model which I refer to as The Discourse Teaching Strategy Model which constitutes the new knowledge generated in this study. Finally, in **Chapter 8**, I answer my sub-research questions using the findings from my study and make some recommendations.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

The purpose of this study was to explore the teachers' Discourse when teaching basic genetics concepts to grade 12 learners in South African classrooms using Discourse analysis as the lens. In particular, this study sought to establish how teachers develop genetics concepts, the interaction patterns and teacher Discourse moves evident and the emerging teacher Discourse strategies during the teaching of basic genetics to grade 12 learners. This study was influenced by Gee's Theory of D/discourse where he considers language and context (Gee, 2015). Thus, this study focused on teachers' use of the language of science in their classrooms.

In this chapter, I discuss how the current study is located in the literature. Based on the title of my thesis, *An Analysis of teachers' Discourse when teaching basic genetics concepts in South African classrooms*, I considered the following four bodies of literature for review. Considering my first sub-research question stated above, I reviewed literature focusing on Discourse analysis, which constitutes my theoretical framework. Next, I discuss the literature on language including the literature focusing on teacher talk. Particularly, the review of literature on teacher talk focused on studies on general talk in science which was then followed by studies focusing on classroom Discourse. Based on my second and third sub-research questions stated in Section 2.4, the third body of literature that was reviewed focused on teaching and learning challenges in genetics education as well as knowledge about teachers teaching genetics. Finally, considering that my study was conducted in the life sciences grade 12 teaching context, a review of the CAPS document, Examinations Guidelines, and the Annual Teaching Plan (ATP) concludes this Chapter.

2.1 Adopted Literature Review Approach

A review of literature is a systematic, explicit, and reproducible technique of identifying, evaluating, and synthesising the existing body of work recorded and produced by practitioners, scholars as well as researchers (Fink, 2019). According Booth et al. (2021) the purpose of literature review is to convey to the reader what knowledge and ideas have been established on a topic, and the studies' collective strengths and weaknesses. They add that a literature review when conducted well, provides the most trustworthy answers to specific review questions and helps identify gaps in the current knowledge that would require further research.

Three types of literature reviews often relied upon in social sciences are systematic review, meta-analysis review, and narrative review. Firstly, a systematic review identifies and synthesises all relevant research on a specific topic and often appraises one hypothesis or links together a series of related hypotheses. Systematic reviews tend to be narrowly focused, implying that they are much less comprehensive than narrative reviews, and employ strict methods both in the selection of literature under review as well as how it is analysed. Secondly, a meta-analysis review is a quantitative review that uses statistical techniques to synthesise results into a single report. It attempts to capture all of the findings from evidence-based, primary, and current research on a particular topic and apply statistical analyses to the data to build an integrated, comprehensive picture of the subject under review. Lastly, narrative review synthesises and assesses primary research into a single, descriptive account. It is characterised by more of a qualitative analysis of previous research.

Based on the purpose of my study (writing a literature review for my thesis) and my research questions, I adopted the systematic review approach. However, this approach included elements from the narrative review techniques where I was summarizing, appraising and synthesizing all the relevant studies developed around my research topic. To conduct a systematic literature review, I considered the following five steps. The first step was *problem formulation*, where I examined the field of classroom Discourse and the issues associated with it. I also made my research problem clear and precise which helped me to direct and frame my readings. The second step was to *identify and locate appropriate readings* which entailed finding materials that were relevant to the field and issues identified in the first step. To do this I started by determining the scope of my literature review, I transformed my problem into a topic which I then broke down into the following terms: classroom Discourse (capital 'D' is deliberate), Discourse analysis, teachers and teaching, genetics concepts, and South Africa. I then used the identified terms as keywords for my literature search in terms of scholarly journals/books, online journals and texts, databases, bibliographies, search engines, and media. During this process, I recorded useful information manually and made use of the Endnote Referencing Manager program for storage and referencing. The next step was to *read and critically evaluate the information* from the selected literature. This was done by examining the studies' strengths and weaknesses and determining which literature made a significant contribution to my topic. The fourth step was *analysis and interpretation,* where I compared and discussed the findings and conclusions of studies that were pertinent to my study. Lastly, I planned the organisation and presentation of my literature review.

2.2 Language Context

2.2.1 The central role of language in science education

Science is considered a practical subject that should be taught by immersing learners in practical activities (Pun & Cheung, 2023). However, for practical work to be meaningful, it needs to be embedded in a conversation where ideas would be checked against experience during a discussion (Pather et al., 2020). This points us to the importance of teachers' language as they are the foremost resource for learners' learning in science classrooms. This study was motivated by the substantive role of language in the formation and development of concepts (Vygotsky & Cole, 1978). Thus, in the study above, language is believed to be at the core of teaching and is intertwined with science education. However, in my study, I did not consider issues of multilingualism or monolingualism instead my focus was on the language of science. Particularly, my study focused on the teachers' use of the language of science in their contexts (Discourse) when teaching basic genetics concepts. So, this study involved the analysis of what was presented to the learners in the life sciences classroom on the topic of genetics which is known to be important and problematic.

It is a requirement of science that learners be able to write, read and communicate orally (Hlabane, 2014). This becomes a challenge to ESL (English Second Language) learners who may not be proficient in the language of instruction. Lack of proficiency in the language of instruction results in learners developing a negative attitude towards teachers and the subject (Mthiyane, 2016). Besides, learners end up failing to communicate their ideas (Motloung et al., 2021) leading to poor performance in science. What makes matters worse is that these learners are examined in English, thus failure to understand questions results in failure academically (Brock-Utne, 2016). Whilst general proficiency is a desirable thing, it is important to note that science is a language on its own (Adams et al., 2015). This links with Lemke (discussed in detail later in Sub-section 2.4.2) who highlights the importance of language in classroom Discourse. This implies that for learners to succeed academically, they need to be proficient in both the language of instruction and the language of science. In this study, my focus was on the language of science rather than the language of instruction. Particularly, I was interested in how the teachers use the language of science (genetics) in their life sciences classrooms. The language of science (genetics content) in my study is what Gee (1996) refers to as discourse with a small 'd' while the Life Sciences classrooms would constitute the context. Thus, the use of the language of science (genetics concepts) in life interaction patterns, teacher Discourse moves and teacher Discourse strategies (context) constitute what Gee (1996) refers to as Discourse. In the next section, I discuss the language of science and its challenges.

2.2.2 The language of science and its challenges

Learning science is considered to be similar to learning a new language (Lemke, 1990) which differs from the language we use in our everyday life (Gee, 2017). This implies that the language spoken in a science classroom is different from everyday English, such that even English first language learners also struggle with it. These difficulties are caused by various characteristics of the language such as the presence of technical terms and, the transformation of everyday words when used in the scientific context (Vladušić et al., 2016). Since these characteristics of the language of science are relevant to my study, l discuss them below.

Technical terms are words that are peculiar to science have a precise meaning and are considered to have the same meaning despite context and user (Haug & Ødegaard, 2014). According to Wellington and Osborne (2001), these words can be classified into four levels of abstraction, the simplest consisting of technical words that simply name real objects (*trachea*). In some cases, new words are introduced in familiar contexts (*trait*), in others new words are introduced in new contexts (*allele, chromosome*). The second level of technical words consists of process words which may show some level of abstraction as some words have demonstrative definitions (*DNA profiling*) whilst others are not demonstratable (*meiosis*). These words signify processes that happen in science. The third and largest level consists of concept words which impose the most difficulties as they indicate more abstract ideas. What makes the matter worse is the fact that these concept words have interlocking definitions, meaning that these words are compactly related to each other (Thörne & Gericke, 2014a). In this study, such words would be *DNA, gene,* and *chromosome* which are common problems around the world (Machová & Ehler, 2023). One cannot understand *genes* without understanding what *DNA is*. It is also important for learners to understand the link between these concepts to bring about *traits*. Thus, this study probed the teachers' use of language in terms of the connections that they made about science terms such as *DNA*, *allele*, *gene,* and *trait.* The fourth and highest level of technical terms consists of mathematical 'words' and symbols which impose the highest level of abstraction in the scientific words hierarchy. The mathematical language used in science, for example, Mendelian genetics is neither derived from nor directly applicable to our experiences. This level of technical words imposes challenges on the learners. Thus, teachers in this study were observed teaching basic genetics, Mendelian genetics included.

The second characteristic of language that results in challenges with the language of science is the transformation of everyday words when used in the science context. Many of the difficult conceptual words used in science have a precise meaning when used in the science context but have a different meaning in everyday English (Vladušić et al., 2016). These polysemous words may look like a foreign language which may be strange to all learners (Thörne & Gericke, 2014a). In this study, I probed the teachers' use of this language to find out the types of thematics they constructed, identify the thematic items (science words) they used and how they constructed semantic relations and thematic patterns to answer my first sub-research question.

Lastly, the language associated with science imposes challenges on learners. This category consists of metalinguistic verbs such as *state*, *describe*, and *define* as well as metacognitive verbs such as *calculate*, *analyse*, and *deduce* (Semeon & Mutekwe, 2021). These words are used by teachers, tests and examinations but never on the playgrounds (Osborne, 2023). However, in this study, I did not focus on this category instead, I focused on the actual science or technical words. Next, I present a discussion on teacher talk.

2.2.3 Teacher Talk

Various researchers have highlighted the importance of language in science education, for instance, Mortimer and Scott (2003); Lemke (1990); and Msimanga et al. (2017). In this regard, teachers have been identified as key players in helping learners master the language of science which is characterised by specific terms (technical) and a certain style of talking (Axelsson & Jakobson, 2020; Walldén & Nygård Larsson, 2023). This science language is what Gee (1996) refers to as discourse (with lower-case 'd'). This study, therefore, focused on the language of science that teachers use when teaching genetics concepts. In this section, I classified teacher talk into productive and non-productive teacher talk which I discuss in the next sub-sections.

2.2.3.1 Productive practices of teacher talk

There are many characteristics of productive teacher talk, some of which are interactions and transitions from one Discourse to another. These characteristics are discussed in this section. Productive teacher talk is characterised by interactions (Howe et al., 2019). The life sciences classrooms are associated with a process described by Gee (2017) as socialisation into a Discourse which links to his later work on situated cognition. This is a process where the novices are allowed to interact with people who have already mastered the Discourse. In light of this, life sciences teachers strive to socialise learners into the science classroom Discourse through a language as legitimate teachers would ideally do.) Lave and Wenger (1991**)** use the term legitimate peripheral participation to characterise the ways in which new members in places of learning gain skills by working and progressing from basic tasks to full participation. Hence, learners who are novices move sequentially as they infuse themselves in the practice of more experienced experts while teachers are legitimate participants who are recognised and supported by the members of their practice. This notion is supported by Lemke (2021) who argues that teachers' use of language may foster science identity as they build science classroom communities. Thus, in ideal life sciences classrooms, teachers are the experts and learners are the novices who interact with the experts (Abtahi et al., 2017) to master the Discourse, which is classic situated cognition (Lemke, 2021). In my study, the experts (teachers) were analysed in terms of their use of the language of science in their contexts (Discourse) when teaching basic genetics. Firstly, this was done by analysing the teachers' practices for the types of thematics developed, thematic items used and how they were connected to build semantic relations and thematic patterns which answered my first sub-research question. Secondly, the teachers' practices were analysed in terms of the interaction patterns which entailed the communicative approaches adopted, the patterns of Discourse and teacher Discourse moves which answered my second sub-research question. Lastly, the teacher's classrooms were probed in terms of the Discourse strategies they used to build thematic patterns during the development of genetics concepts. This was done in terms of thematic development strategies, social interaction strategies and multimodal representations which include visual, verbal and gestures.

The importance of interactions in teacher talk is supported by a study conducted by Haug and Ødegaard (2014) who explore word knowledge when teaching for conceptual understanding in an inquiry-based science setting. Their results show that learners' level of word knowledge develops towards conceptual knowledge when they discuss their ideas and findings. Thus, productive teacher talk is characterised by learner-learner and teacher-learner interactions.

The transition from one discourse (small ’d’ is deliberate since it represents language) to another is another characteristic of productive teacher talk (Miranda & Wahyudin, 2023). Karlsson (2016) identifies code-switching as one way that could assist English second language learners to understand science concepts. The importance of this practice is supported by studies conducted by Schoerning (2014) as well as Haglund et al. (2015). Schoerning (2014) shows that learners exposed to everyday English instruction perform better on examinations than their counterparts exposed to standard scientific vocabulary. Better performance by learners subjected to everyday English instruction shows us the importance of changing from one discourse (language) to another to create opportunities to learn. In contrast, for Scott et al. (2006) this shift from one Discourse to another implies the use of learners’ everyday views to teach the scientific view. This includes changing from the science academic language to the use of everyday language whenever necessary during science lessons to ensure that students comprehend the science concepts in question. It is against this background that my study examined the changes that occured at different points of the lesson, as the teacher changed from one discourse (language) or Discourse to another. This was considered as part of the context in which the teachers used the language of science. In the next section, I discuss the non-productive practices of teacher talk.

2.2.3.2 Non-productive practices of teacher talk

There are many characteristics of non-productive teacher talk for example, teachers doing the talk for learners, failure to convey intended meanings as well as the teachers’ language and instruction can be sources of confusion. These three characteristics which are based on constructivism are discussed in detail in this section. Constructivism is based on the premise that learning depends on a process of connecting new knowledge to pre-existing knowledge. For this reason, non-productive practices of teacher talk are characterised by the teacher doing the talking for the learners through paraphrasing and neglecting learners’ everyday experiences. This is supported by a study conducted by Haug and Ødegaard (2014) referred to earlier whose findings show that conceptual understanding is not promoted when teachers paraphrase learners’ responses into correct answers and neglect their everyday perceptions. Owing to this, my study focused on how teachers responded to learners’ contributions which is espoused in my second sub-research question stated in Section 2.4 through teacher Discourse moves. In this study, everyday perceptions of scientific phenomena were classified as everyday Discourse. Hence, my study considered the importance of everyday perceptions of scientific phenomena by focusing on the changes that occurred from one Discourse to another at different points of the lesson as teachers engaged in dialogic interactions. This was meant to answer part of my second sub-research question in terms of communicative approaches.

Failure to convey intended meanings is another characteristic of non-productive teacher talk. This is supported by a study conducted by Yun and Park (2018) who show that teachers fail to convey the intended meanings in their practice. This could be due to a lack of awareness of the possible difficulty of science words in their classroom for learners as observed by Quílez (2019). Thus, my study explored how teachers developed meanings of genetics concepts through the identification of thematic items (genetics terms) and how they used them to construct semantic relations and thematic patterns as spelt out in my first sub-research question in Section 2.4.

The teachers' language and instruction can be a source of confusion. This notion is supported by a study conducted by Thörne and Gericke (2014a) which reveals that none of the teachers in their study talk about *genes* as exclusively encoding proteins. This implies that learners' lack of understanding of proteins as an intermediate link between genes and traits could be explained by limitations in the way the genetics phenomenon is taught. In light of the discussion above, based on my first sub-research question, this study intended to explore how teachers teach the genetics concepts such as *genes* and *monohybrid crosses* which result in various *traits* that we see in organisms. The language explored in this study is the language of science which was analysed using Lemke's Thematic Analysis which I discuss in the next section.

2.3 Research Studies

2.3.1 Classroom Discourse

Notable research on classroom Discourse has been conducted abroad, where researchers did some work to build upon the work of Barnes (1976,1992) for example Lemke (1989); Mercer (1995); Scott (1998). In 1982, through a thematic analysis approach, Lemke studied science classroom talk and its context in classrooms of about 60 lessons with 20 teachers and 25 classes of pupils talking physics, biology, chemistry, geology, and astronomy in a large American city. Through his analyses of various series of episodes or topical related sets in the transcript of the lessons, he identifies ‘thematic items’ or terms which are the science concepts in the Discourse (Lemke, 1990, p. 88). My analysis of Discourse was underpinned by Lemke’s thematic analysis which I extended by amalgamating it with Mortimer and Scott’s communicative approaches, Patterns of Discourse, and teacher interventions (teacher Discourse moves). I merged these two because, like Mortimer and Scott (2003), I believe that communication is central to the classroom Discourse.

In 1995 Mercer analysed talk in primary school classrooms. In particular, he focused on talk between teachers and learners as well as learners working together in a classroom. His analysis was underpinned by a specific view that focuses on the relationship between language and thought. In 1998 Scott through a review of a selection of studies examined how meanings are built during interactions in science classrooms. His analysis showed that teachers use extraordinarily skilled ways to engage whole classes of learners in learning activities though the skills remain concealed since research and instructive attention have been focused more on learner thinking and instructional activities. Mortimer and Scott (2003), later conduct a Discourse analysis where they focus on the classroom interactions between learners and teachers during the teaching of science in Brazil. This analysis provides a very useful research model around three aspects of activities that define the role of the teacher during the lesson viz, focus, approach, and action. A study conducted by Tang (2016) analyses the relationship between the communicative approach and the modes of representation used by physics teachers during classroom talk in Singapore. His findings show that as the mode of representation shifts from one form to another for example from enactive (action-based) to iconic (image-based) to symbolic (language-based), there is a concurrent and correlated shift in the communicative approach from interactive/dialogic to interactive/authoritative to non-interactive/authoritative. Specifically, the shift from enactive through iconic to symbolic representations is associated with the interactive/dialogic approach while the shift towards the interactive/authoritative and non-interactive/authoritative approaches is associated with the use of symbolic modes of representation. This concurrent and coordinated shift influences how one conceives the use of representations together with the cooccurring classroom Discourse.

In the same vein, Taylor (2014) conducted a study in UK classrooms that offers evidence to demonstrate how incorporated modes such as gesture, posture, facial expression, and gaze work in concert with speech for the joint construction of knowledge in learners. Taylor's findings reveal that learners learn and share ideas through multiple modes of representation. A study conducted by Smart and Marshall (2013) analyses interactions in classroom Discourse, specifically teacher questioning, and related learner cognitive engagement in middle school science. Results from this study indicate positive correlations between learners' cognitive engagement and the following various aspects of classroom Discourse: questioning level, the complexity of questions, questioning ecology, communication patterns, and classroom interactions. Elsewhere, a study conducted by Colley and Windschitl (2016) examines how responsiveness to learners' ideas creates opportunities for sensemaking talk by learners. This study reveals that rigorous whole class talk is associated with teachers' use of open-ended questions, follow-up prompts, and references to representations. Particularly, their findings show us that rigorous talk occurs when the conditions listed above are used concurrently. Nonetheless, like Scott et al. (2006) they show that simultaneous attempts to be responsive to learners' ideas while attending to sensemaking talk by learners generate tensions that oppose efforts to create such Discourse environments. This challenge created here is similar to the tension identified by Scott et al. (2006) as tension that occurs when teachers attempt to adopt the dialogic approach as they encourage learners to make their views explicit while paying attention more authoritatively to the accepted scientific view (refer to section 2.1.4 for communicative approaches). Lehesvuori et al. (2018) identify this tension as an internal struggle.

Another study was conducted in Turkey by Kaya et al. (2016) to determine Discourse patterns and communicative approaches that are utilised for teaching the nature of science (NOS) using Discourse analysis using eight teachers. Their results reveal that teachers use three different Discourse patterns (triadic, chain, and adjacency pair) and three different communicative approaches (interactive–dialogic, interactive–authoritative, and non-interactive–dialogic) for teaching NOS. Furthermore, the results show that the most common Discourse pattern is the triadic pattern I-R-E (initiation-response-evaluation) and the interactive–authoritative approach is the predominant approach. The result on the I-R-E pattern is consistent with Osborne (2023) who argues that the prevalent form of Discourse patterns in most classrooms specifically science classrooms is triadic dialogue or I-R-E. This overwhelming dominance of the I-R-E pattern in science classrooms is problematic because learners are not provided with opportunities to consider open-ended questions (Alexander, 2020). According to Osborne (2023), this form of linguistic practice has three problems. Firstly, this type of dialogue is unnatural because normally questions are asked by the person who does not know rather than the one who does know. Secondly, it minimises the learners' opportunity to practice the language of science. Lastly, this type of dialogue presents knowledge as bivalent in the sense that it is considered to be true or false which emphasises an absolutist epistemology that leaves no room for uncertainty. However, Msimanga (2021) argues that in more engaged interactions, the teacher genuinely engages learners in sustained I-R-P-R-P-R-F-P…/E open or closed chains where teacher probes (P) can open up the interaction closer to a true conversation through learner questions and encouraging unsolicited learner ideas. Literature reports that this pattern of Discourse is rare in science classrooms (Msimanga, 2021; Osborne, 2023). Therefore, my study also interrogated the teachers' practices for the patterns of Discourse discussed above to determine whether the teachers provide their learners with opportunities to practice talking the language of science.

For analysis, my study drew on Kaya and colleagues' study of Discourse patterns and communicative approaches in a bid to answer my second sub-research question though I did not consider the adjacent pair type of Discourse pattern. A similar study was conducted by Hiltunen et al. (2020) to examine how student teachers talk with students during their inquiry-based biology instruction. Their findings show that the student teachers use dialogic talk in their inquiry-based instruction only occasionally. This finding concurs with Aguiar (2016) though teachers are aware of how beneficial dialogic talk is to science learning (Scott et al., 2006). However, a separate study conducted by Juuti et al. (2020) shows that dialogic interactions among the students, which might be considered unacceptable behaviour or off-topic activities, allow students to (temporarily) regain some level of control over the authoritativeness of teaching. In the same vein, Rees and Roth (2019) conducted a study to examine how Discourse forms changed over time as the lesson transitioned to learner-centred scientific inquiry. The findings reveal that as the lesson evolves into learner-centred scientific inquiry a shift to the dialogic Discourse becomes evident.

Axelsson and Jakobson (2020) examine a teacher's and multilingual learners' use of multiple resources and their potential for learners' meaning-making of sound and sound transmission with 14–15-year-olds, Swedish grade 8, who were Swedish second language speakers. They explore how different strategies and multiple resources interact to create thematic patterns in a multilingual science classroom. They use thematic development strategies, control, and social interaction strategies as well as strategies of bridging multiple resources as analytical tools. Their findings show that as teachers co-construct the content using various resources, they develop thematic patterns by continuously shifting between everyday and scientific language because of the teacher's awareness of the unit's abstract and technical content. In addition, Axelsson and Jakobson's findings also show that a strategy of control performed by the teacher marks the importance of using physics words. Strategies of social interaction underscored by learners' earlier experiences, personal and humorous connotations expressed in everyday language enhance meaning-making. Furthermore, several multiple resources, such as models, gestures, bodily actions, drawings, reading, and writing are used by teachers when developing thematic patterns. My study drew from Axelsson and Jakobson's study in the sense that I focused on the strategies that teachers use to build thematic patterns as they teach basic genetics to grade 12 learners. In particular, like Axelsson and Jakobson, my study analysed the thematic development strategies and social interaction strategies that are used by teachers to construct semantic relations (thematic patterns). However, in my study, I identified multiple resources as multimodal representations which include visual, verbal, and gestures. Thus, my study was generally similar to Axelsson and Jakobson's study in the sense that it was greatly influenced by Lemkes' thematic analysis though mine was extended by the incorporation of Mortimer and Scott's communicative approaches, patterns of Discourse, and Teacher interventions (teacher Discourse moves).

The discussion above shows on the one hand, that Mercer's analysis is based on a view that considers language and thought while Scott shows that teachers employ extraordinary skills to involve learners in learning activities, though these strategies are tacit. On the other hand, Mortimer and Scott's analysis provides a model that is characterised by three aspects defining the role of the teacher during the teaching and learning process. Tang analyses the relationship between communicative approaches

Locally, here in South Africa, there has been much research on classroom Discourse for example Msimanga and Lelliott (2014); Probyn (2015); Taylor and Lelliott (2015); Mavuru (2019); Murphy et al. (2020); Semeon and Mutekwe (2021); but less on classroom Discourse that has focused explicitly at the construction of knowledge. Msimanga and Lelliott focus on how learners engage with the science content using their home languages during small group discussions. Their findings show that learners spend most of their discussion time on task as they make and support claims, question, and challenge each other's thinking though the levels of critique vary from one group to another. Similarly, Probyn conducts a study where she explores how teachers utilise the learner's home language as well as the English language and how these practices may improve the learners' opportunity to learn science. Her findings show one teacher's practice to be distinguished because of his systematic and purposeful use of learners' home language which she referred to as 'pedagogical translanguaging'. Though the studies discussed above look at the use of home language as a resource for teaching and learning, Msimanga and Lelliott's focus is on learners while Probyn's focus is on teachers. Though my study considered language which I referred to as discourse with a lowercase 'd', it was not focused on translanguaging, codeswitching or the medium of instruction which is English like Probyn. Instead, my study focused on the language of science which includes the challenging genetics terms and concepts.

Another study conducted by Taylor and Lelliott (2015) where they examined the nature of classroom talk in eight physical science classrooms revealed three types of talk viz, exposition, question and answer, and conversation. Furthermore, dialogic talk was found to be evident in all teachers' classrooms observed. Findings from this study about dialogic Discourse contradict the findings obtained in a study conducted by Mavuru (2019) who shows that despite planning for dialogic teaching, student teachers aborted their plan due to various reasons. For instance, inability to sustain dialogue, failure to probe learners' ideas, lack of knowledge of learners' ideas as well as lack of management skills. In terms of the types of talk revealed by Taylor and Lelliott's study, my study also considered two of them which I referred to as thematic development strategies. In my study, the exposition had the same name while the question and answer strategy was referred to **teacher question series** (refer to Chapter 7 for more information). The dialogic talk which I referred to as dialogic Discourse in my study is also considered for analysis together with authoritative Discourse which is not in focus in the two studies discussed above. In this study, I explored dialogic Discourse in a bid to address the first aspect of my second sub-research question which speaks of communicative approaches.

A study conducted by Murphy et al. (2020) where they explore the structure and content of Discourse in South African classrooms reveals that the Discourse is characterised by an eccentric stance towards text, the discussions are mainly controlled by the teacher and there is very little evidence of learners' critical thinking. Like the studies discussed above Murphy and colleagues focus on the type and structure of Discourse in classrooms. Contrary to this, Semeon and Mutekwe (2021) focus on the perceptions of South African physical science teachers' perceptions of language use in their classrooms. Their findings show that physical science teachers encounter difficulties with the meanings of non-technical words that are used in the science context. Thus, they conclude that physical science teachers are not proficient in the discourse (language) of the science classroom. Though Semeon and Mutekwe's study touches on non-technical words used in science which constitutes the science knowledge, its classroom Discourse does not focus on the construction of science knowledge. However, the construction of science was the focus of my study. On the one hand, the only study reviewed above that seems to focus on the construction of knowledge considers the development of semantic relations (thematic patterns), thematic development strategies, control, and social interaction strategies as well as strategies for bridging multiple resources as analytical tools and was conducted abroad. On the other hand, my study expanded Lemke's work by amalgamating his Thematic Analysis with Mortimer and Scott's communicative approaches, patterns of Discourse, and teacher interventions (teacher Discourse moves). It, therefore, appears that there is a gap in terms of research, that examines the construction of science knowledge through the teachers' Discourse while considering the centrality of communicative approaches; a gap that this research intended to fill.

Much research has been conducted on Discourse moves, internationally, for example, Bansal (2018), Ellis et al. (2019); Lim et al. (2020); Carpenter et al. (2020), and locally for instance, Sefhedi et al. (2020); Buma and Nyamupangedengu (2020); Khoza and Msimanga (2021); and Khoza (2023). On the one hand, Bansal investigates various types of teacher Discourse moves that promote dialogic Discourse in secondary school science classrooms. Their analysis reveals that the three components (developed discursive move framework) of characterising Discourse in science classrooms viz, Foundation (F) that aimed at developing a culture of Discourse, Initiation (I) moves meant to elicit learners' diverse perspectives and Perpetuation (P) moves engaging learners actively during an exchange of ideas were evident in dialogic classrooms. In particular, two teachers in this study are found to be 'enablers of talk for thinking'. On the other hand, Ellis, and colleagues present a framework of teacher moves referred to as Teacher Moves for Supporting Student Reasoning (TMSSR). Their analysis organises the moves used by teachers into four categories which are eliciting, responding facilitating, and extending. In the same vein, Carpenter et al. (2020) investigated how ten secondary science teachers go beyond eliciting learner ideas to working with learners' ideas to support sensemaking. This study reveals that teachers who engage in high-quality discussions use jointly planned Discourse moves to elicit, mark, and build learner ideas by probing learners for justification or reason for their answers. The studies conducted by Ellis et al. (2019) and Bansal (2018) develop frameworks that can be used to probe the teachers' practices in terms of Discourse moves while the study conducted by Carpenter et al. (2020) classifies Discourse moves into three categories. Therefore, my study drew from these three studies to develop a scheme that I used to analyse the teachers’ practices for teacher Discourse moves to address part of my second sub-research question.

Local scholars in this field of classroom Discourse have also investigated Discourse moves. For instance, Sefhedi et al. (2020) analyse the use of teacher Discourse moves and pedagogical principles as an aspect of the Quality Talk model. Their findings provide evidence that teacher training and support in the use of teacher Discourse moves, and pedagogical principles could enhance students’ development of critical-analytic thinking. In the same vein, another study conducted by Buma and Nyamupangedengu (2020) examines classroom talk to determine the type of student participation encouraging moves concepts and the associated quality of instructional strategies used by a university lecturer during lessons on basic genetics. Their findings reveal two student participation stimulating talk-related instructional strategies eliciting diverse and deeper responses from the students. These strategies include higher-order initiating and rejoinder moves and types of moves. A similar study conducted by Khoza and Msimanga (2021) examines the nature of initiating and rejoinder moves and their effect in science classrooms. Their data contradict the claim that closed-ended initiating questions always lead to minimised interaction and that only open-ended initiating questions lead to prolonged interaction depending on the nature of rejoinders. The three local studies discussed above seem to be linked to one another in the sense that they all focus on teacher Discourse moves and their effect on the quality of talk or participation in the science classroom. In my study, I drew on three studies reviewed above though I did not adopt the terms they use for the moves such as initiating and rejoinder moves. Instead, as alluded to earlier in this review, I drew on literature to develop a coding scheme where I classified the Discourse moves into four categories that I used for analysis (see Table 4.3 Chapter 4). Furthermore, the study conducted by Khoza and Msimanga (2021) shows that teacher Discourse moves are associated with closed and open-ended questions. Thus, to address part of my second sub-research question dealing with teacher Discourse moves, I drew from them and other scholars such as Surif et al. (2014) as well as Mavuru and Ramnarain (2020) for closed and open-ended questions during my analysis.

Overall, the literature reviewed in this chapter provides evidence that scholars in this field have addressed the important issue of classroom Discourse concerning the structure of Discourse as well as Discourse moves. Nonetheless, very little work has been done in terms of classroom Discourse concerning the construction of knowledge. It, therefore, appears that there is a gap in terms of research internationally and locally (South Africa), that examines the construction of genetics concepts through the teachers' Discourse while considering the centrality of communicative approaches; a gap that this research sought to fill.

2.3.2 Teaching and learning difficulties in genetics education

Literature has identified the abstract and complex nature of genetics, the separation of genetics and inheritance, reproduction and meiosis in the curriculum, the different levels of biological organisation, and the inconsistency of textbooks as factors contributing to the complex nature of genetics (Machová & Ehler, 2023). I discuss these factors in the next subsections.

2.3.2.1 Domain-specific challenges

Several domain-specific challenges have been identified from the research literature on genetics (Vlckova et al., 2016). However, the main source of difficulty underpinning the other difficulties in genetics education is the fact that genetics concepts belong to various levels of biological organisation which are micro, macro, and symbolic (Livni-Alcasid et al., 2018). This problem is made worse by the fact that these levels are taught at different times and are not usually linked (Kılıç et al., 2016). In light of this, in this review, l have classified difficulties in genetics education into two groups, which are micro and macro challenges. Some authors classify genetics into three levels including the symbolic where symbols are used to represent genetics entities such as nucleotide bases and triplet codes. However, in this discussion, I classified the difficulties related to the symbolic problem into the micro problem category because symbols represent the micro-entities. According to Livni-Alcasid et al. (2018), the macro level refers to morphological traits that can be accessed by our senses such as the representation of phenotypes. Such characteristics are hair colour, skin colour, and height. The microscopic level is the representation of alleles, DNA, and chromosomes (Livni-Alcasid et al., 2018). However, most problems are related to the micro problem and the explicit link between the micro and the macro. Consequently, to address my first research question stated in Section 2.4, I considered both macro and macro genetics as exemplified by the analysis of teachers' practice when teaching the concepts of *genes* and *genetic crosses.*

The mathematical and symbolic nature of Mendelian genetics is the source of challenges faced by learners in genetics education about the micro problem. Despite understanding the probabilistic nature of problems concerning real life and having no problems with determining chances, learners fail to apply similar chance events in new contexts (Livni-Alcasid et al., 2018). Machová and Ehler (2023) also argue that it is the mathematical expression used in Mendelian tasks, which are symbolic, that causes challenges for students in genetics education. Moreover, teachers and textbooks are blamed for their inconsistency when it comes to the use of symbols during Mendelian genetics tasks (Livni-Alcasid et al., 2018). To answer my first sub-research question, I interrogated the way teachers deal with the genetic crosses to see if they are relating the crosses to the underlying principles such as *meiosis*, *segregation*, *independent assortment*, *and reproduction.*

Another source of challenges related to the micro problem is cytological processes where students experience difficulties in understanding mitosis and meiosis (Machová & Ehler, 2023). A study conducted by Rafat and Ali (2023) confirms this through their findings. Their findings show that learners have a very limited understanding of cell division and are confused and inconsistent in their knowledge. In addition, they found that learners cannot distinguish between mitosis and meiosis and are unaware of the purpose, processes, and products of cell division. Cytological processes such as meiosis are underlying processes in the study of genetics (Sato et al., 2021). As mentioned earlier, in a bid to answer my first sub-research question, I analysed the way teachers present the *genetic crosses* to see if the teachers emphasise the underlying process of *meiosis*.

Other problems relating to both the macro and micro problems are the challenges experienced by learners in linking or establishing relationships between concepts. A study conducted by Haskel-Ittah and Yarden (2017) to explore the learners' ability to link genes to traits through proteins revealed that learners show a poor understanding of the relationship between genes, traits, and proteins. A similar study conducted by Gusmalini and Wulandari (2020) to identify students' misconceptions and causes of students' misconceptions of genetics concepts shows similar results. This study reveals that learners show a poor understanding of the relationship between genes, chromosomes, and DNA. Furthermore, the same study confirms that domain-specific vocabulary and terminology are a source of difficulties experienced by learners in genetics education. Their findings show that most learners have challenges in understanding the terms used in genetics especially DNA, chromosome, and gene besides the challenges they have in constructing relationships between these terms. Owing to this, my analysis considered these terms and their relationships to answer my first sub-research question.

In light of the discussion above, in South African life sciences classrooms, learners are introduced to the extensive genetic vocabulary by the teachers, textbooks, and Examination Guidelines. However, these three sources do not use these words consistently resulting in confusion and error (Rusmana et al., 2021). This is true for South Africa's grade 12 life sciences textbooks Gebhardt et al. (2020) and Sterrenberg et al. (2014) referred to later in this section. They are not consistent in terms of their use of words. This implies that teachers need to be very selective and specific when they use extensive terminology and avoid using a lot of synonyms as this can promote confusion. Owing to this, in my analysis I explored the teachers' use of synonyms as they construct semantic relations to answer my first sub-research question.

Difficulties in genetics education are also associated with the relationship between meiosis and the topic of genetics as well as sequencing of topics during teaching. As alluded to earlier in this review, textbooks have been identified as one of the sources of difficulty in genetics education. In light of this, I consulted two textbooks (Gebhardt et al., 2020; Sterrenberg et al., 2014) that are used in grade 12 for Life Sciences as well as the CAPS document and found that they prescribe that the concept of DNA be taught first before meiosis, which is followed by *reproduction* and *genetics* (includes inheritance). Thus, *meiosis* and *genetics* are treated as separate topics and there is a lapse of time between the introduction of *meiosis* and *genetics* both in South African life sciences textbooks and the CAPS document. This could result in learners failing to make links between *meiosis* and *genetics* as sequencing is a critical issue.
In the same vein of sequencing topics, Livni-Alcasid et al. (2018) suggest that teaching genetics should start from the macro level to the micro level so that learners are exposed to the genetics aspects in higher animals before the micro level. Sequencing of concepts becomes very important in the teaching of genetics. Therefore, life sciences teachers should possess what Mavhunga and Rollnick (2013) refer to as curricular saliency, which includes the teachers' knowledge of what learners need to be taught first for them to understand certain concepts.

2.3.2.2 Challenging genetics concepts and learners' understandings of genetics concepts

Genetics has been identified as one of the most difficult topics in Biology/life sciences (Vlckova et al., 2016). This could be due to the challenging nature of the concepts involved in this topic which are presented in Table 2.1.

Table 2. 1: Challenging genetics concepts

Genetic term	Definition	Author	Learner difficulties
Deoxyribonucleic acid (DNA)	Polynucleotide is formed from covalently linked deoxyribonucleotide units.	(Alberts et al., 2022)	Sound similar to RNA
Ribonucleic acid (RNA)	A nucleic acid is composed of a single polynucleotide chain of ribonucleotides that is found in all cells.	(Gebhardt et al., 2020)	Similar structure and sounds like DNA,
Chromatin	A complex of DNA, histones, and non-histone proteins that is found in the nucleus of a eukaryotic cell. The material from which chromosomes are made.	(Campbell et al., 2018)	Sound similar to the concept of chromosome
Chromosome	Threadlike structures in the nucleus of a eukaryotic cell that become visible by light microscopy as the cell begins to divide.	(Alberts et al., 2022)	Interlocking characteristic (other terms used its definition)
Chromatid	One of the two identical halves of a chromosome that has been replicated in preparation for cell division.	(Alberts et al., 2022)	Interlocking characteristic (other terms used in its definition)
Sister chromatids	Refers to the two copies of the replicated DNA that are held together at a waist-like constriction called the centromere.	(Alberts et al., 2022)	Interlocking characteristic (other terms used in its definition)
Allele	One of several alternative forms of the same gene may produce distinguished phenotypic effects.	(Campbell et al., 2018)	Many technical terms incorporated into the definition
Gene	A region of DNA that is transcribed as a single unit that carries information for a discrete hereditary trait	(Alberts et al., 2022)	Polysemous nature. Use of different words to define the term
Dominant allele and Recessive allele	The dominant allele has control over the recessive allele. Dominant allele can show up in both homozygous and heterozygous conditions whilst the recessive allele can only show up in the homozygous condition	(Sterrenberg et al., 2014)	Interlocked with other genetics terms
Genotype	The genetic constitution of an individual cell or organism. The particular combination of alleles found in a specific individual	(Alberts et al., 2022)	Sound similar to phenotype
Phenotype	Phenotype is the physical appearance or functional expression of a trait	Sterrenberg et al. (2014)	Sound similar to genotype
Homologous chromosomes	A pair of chromosomes of the same length, centromere position, and	(Campbell et al., 2018)	Sound is similar to homologue

Genetic term	Definition	Author	Learner difficulties
	staining pattern that possess genes for the same characters at corresponding loci. One is maternal and the other is paternal.		
Homologue	One of the pair or more genes that are similar in sequence because they are derived from the same ancestral gene.	(Alberts et al., 2022)	Sound similar to homologous chromosomes

In light of Table 2.1 above, it becomes imperative for researchers to traverse teaching situations and the language used in the classroom to understand why students experience challenges with basic genetics concepts (Thörne & Gericke, 2014b). Therefore, this study focused on South African teachers' use of language in their contexts when teaching basic genetic concepts. In particular, in my analysis of the language (discourse) part of the science classroom Discourse, I considered the use of related terms[1]. Since the focus of this study was on teachers, next I discuss knowledge about teachers teaching genetics.

2.3.3 Knowledge about teachers teaching genetics

Challenges experienced by learners when learning genetics may be caused by a lack of understanding of the concepts involved and the way teachers teach the topic (Altunoğlu & Şeker, 2015). This implies that the way genetics concepts are presented to learners can impose difficulties, misconceptions, or misunderstandings on learners. This highlights the importance of consulting research literature on the difficulties and misconceptions by teachers as they plan for their genetics lessons as suggested by Nyamupangedengu (2015). This literature does not only make the teachers aware but also prescribes suggestions that they can use to overcome these difficulties and misconceptions. Subsequently, this may result in effective teaching of genetics concepts. This notion is supported by Cao et al. (2019) who maintain that teachers whose teaching is influenced by research literature conduct lessons that are effective and beneficial to their learners. In the next paragraphs, I discuss some of the misconceptions and difficulties identified by research literature that teachers need to be aware of to overcome them and become effective teachers.

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[1] *haploid, diploid, mitosis, meiosis, somatic cell, gamete, chromatin, chromosome, sister chromatid*, *allele, gene, trait, homologous chromosome, homologue, homozygous, heterozygous, dominant, and recessive, genotype* and *phenotype, true breeding, pure breeding, stamens, stigma, pollination, fertilization, self-pollinate, offspring, first filial generation, second filial generation, sexual reproduction, asexual reproduction, phenotypic ratio, and genotypic ratio.*

Failure to link concepts such as *meiosis* to Mendelian *genetics* was identified as one of the major difficulties experienced by learners resulting from teachers' instruction (Etobro & Banjoko, 2017). Learners fail to link meiotic processes like segregation and assortment when solving *monohybrid* and *dihybrid inheritance* problems. In light of this, Wright et al. (2022) suggest that *meiosis* should be taught just before *genetics*. On the same token, two similar studies discussed in Section 2.6.1 conducted by Haskel-Ittah and Yarden (2017) and Gusmalini and Wulandari (2020) show that learners have a poor understanding of the relationship between *genes*, *proteins,* and *traits* as well as *DNA*, *Genes,* and *chromosomes* respectively. This type of language cannot be encountered by learners in playfields or everyday language; it is introduced to them by their teachers (Osborne, 2023). It is only through consulting research literature that teachers become aware of these challenges and their sources. Thus, to avoid such challenges, the studies reviewed above recommend that teachers need to be explicit when teaching relationships between *genes*, *proteins*, and *traits* as well as *DNA*, *genes*, and *chromosomes*. Ultimately, awareness of such problems and their sources can assist teachers to become more effective. My study interrogated the teachers' practices in terms of the terms discussed above which answers my first sub-research question.

Besides teachers, another source of challenges is the learners' preconceived ideas that may not be scientifically correct (Osman et al., 2017). A recommendation from their study is that teachers need to think carefully about the ideas that learners bring to the classroom for them to learn complex genetics concepts. Hence, knowledge of the learners' preconceived ideas about genetics enriches teachers and makes them effective. In this study, teachers' consideration of learners' preconceived ideas will be probed as factors associated with language in a classroom Discourse which helps answer my second sub-research question. Since this study is conducted in a grade 12 life sciences context, I present important instruments of the life sciences curriculum viz, the CAPS document, Examination guidelines as of 2021, and the Annual Teaching Plan in the next section.

2.4 Theories Framing the Study

The overarching theory in this study was Gee's Theory of D/discourse because this study sought to characterise the teachers' Discourse during the teaching of basic genetics to grade 12 learners. Particularly, it was guided by the following sub-research questions.

1. *How do teachers develop genetics concepts during the teaching of basic genetics to grade 12 learners?*
2. *What forms of interaction patterns and teacher Discourse moves are evident during the teaching of basic genetics to grade 12 learners?*
3. *What kinds of emergent teacher strategies can be extracted from the Discourse of teaching basic genetics to grade 12 learners?*

To address my first and third sub-research questions, I adopted a Discourse analysis approach developed by Lemke (1990) called Thematic Analysis. I used this to explore how teachers develop the genetics concepts (the language of science) and the emergent teacher Discourse strategies (context) during the teaching of genetics. To address my second sub-research question, which probed the teachers' interaction patterns and teacher Discourse moves, I amalgamated Lemke's Thematic Analysis with Mortimer and Scott's Communicative Approaches as well as patterns of Discourse. Next, I discuss the overarching theory of my study.

2.4.1 The Overarching Theory: Gee's Theory of D/discourse

The objective of this study was to explore the teachers' Discourse by focusing on their use of language in their contexts. Based on the sub-research questions stated above, the overarching theory in this study was Gee's Theory of Discourse/discourse (Gee, 1996). The foundation for Gee's theory of D/discourse is demonstrated by the difference between Discourse and discourse as indicated by the use of the lower-case 'd' and upper-case 'D'. Sociolinguists usually use the word Discourse when referring to verbal interactions and the way utterances are sequenced between speakers and listeners (Jaspers, 2023). Conversely, Gee's distinction is intended to consider the connections between social relations, social identities, and contexts as well as identified situations of language use (Gee, 1996).

Discourse with a capital 'D' is defined as "…a socially accepted association among ways of using language, other symbolic expressions, and artifacts, of thinking, feeling, believing, valuing, and acting that can be used to identify oneself as a member of a socially meaningful group or social network" (Gee, 1996, p. 131). This means that Discourse does not only consider how people talk and listen to each other, read, and write but also classifies how people act, interact, and their beliefs, values, and feelings into patterns that are peculiar to specific social networks or affinity groups (Gee, 2001). This implies that Discourse analysis does not only explore the use of language but also considers other factors other than language. Based on the discussion above, it is important to note that in this study, the word Discourse was used with upper-case ‘D’ because my conception of Discourse was influenced by Gee’s Theory of Discourse/discourse (Gee, 1996). Therefore, this study focused on the teachers’ Discourse when teaching basic genetics where analysis of language-in-use included other factors such as context. In this study, on the one hand, language-in-use referred to the language of science (concepts) that the teachers develop during the teaching of genetics. So, my first sub-research question explored this by examining how teachers develop genetics concepts. On the other hand, context refers to the other things that are associated with the language of science such as interaction patterns and teacher Discourse moves as well as teacher Discourse strategies which are espoused in my second and third research questions respectively.

Gee (2010) argues that there are numerous ways of conducting Discourse analysis however, how it is done depends on what we need to do with the linguistic data available. The main focus of this study was to explore the teachers’ Discourse during the teaching of basic genetics to grade 12 learners. Based on my three sub-research questions, firstly, I explored the creation and identification of thematics, by focusing on the thematic items used, how they were used to build semantic relations, and subsequently the construction of thematic patterns. Secondly, I demonstrated the patterns of interaction that were evident in terms of communicative approach, patterns of Discourse, and teacher Discourse moves. In other words, I focused on how teachers directed their science talk during the teaching of genetics concepts using one or more communicative approaches through a variety of teacher Discourse moves. Lastly, I analysed the Discourse strategies that the teachers used to negotiate the meaning-making of genetics concepts with their learners. Consequently, a specific Discourse analysis technique developed by Lemke (1990) called Thematic Analysis amalgamated with Mortimer and Scott’s Communicative Approaches and Discourse patterns was adopted in this study as a lens. It was particularly used for exploring and understanding the teachers’ Discourse during the teaching of basic genetics to grade 12 learners. The overarching theory in this study was Gee’s Theory of D/discourse which emphasises language and context. Next, I review the literature on language.

2.4.2 Lemke's Thematic Analysis

To explore the language part of the teachers' Discourse, this study adopted Lemke's Thematic Analysis. The type of language focused on in this study is the language of science with particular reference to the genetics topic. The thematic analysis approach developed by Lemke (1989) has its foundation in systemic functional linguistics (SFL). Recently, SFL and Lemke's frameworks have been adopted by scholars such as Axelsson and Jakobson (2020); Lin and Lo (2017) Walldén and Nygård Larsson (2023) to analyse classroom Discourse. Particularly, Lin and Lo use Lemke's Thematic Analysis to explore translanguaging and the triadic dialogue in content and language-integrated learning classrooms while Walldén and Nygård Larsson use the Systemic-Functional Linguistics (SFL) perspective on language as a resource for meaning-making. Lastly, Axelsson and Jakobson employ both SFL and Lemke's Thematic Analysis frameworks to examine teachers' and multilingual learners' use of multiple resources and their potential for learners' meaning-making of sound and sound transmission. Next, I present Systemic Functional Linguistics (SFL).

2.4.2.1 Systemic Functional Linguistics (SFL)

Systemic functional linguistics which was developed by Halliday (1978) can be used as both a theory of language and a methodology for analysing texts and contexts of their use. This resonates with Gee (1996) who argues that Discourse with an upper-case 'D' entails exploring the use of language with a lower-case 'd' in its context of use. Hence, Halliday and Gee consider context and language to be complementary. For Halliday (1978) researchers who use systemic functional linguistics as a theory or method make four important claims about language as used by people to accomplish social ends. The first claim says that language use is 'functional' meaning that it is intended to accomplish an end. The second claim says that language use is the end is 'semantic' meaning is intended to make meanings. The third claim says that social and cultural 'contexts' influence people in terms of how they make meaning. Lastly, this whole endeavour of making meaning is a semiotic process involving 'choosing' from linguistic resources.

Halliday (1978) maintains that the functional-semantic approach to language which is what language does and how it does it is extremely useful for comprehending social dynamics like classrooms. In other words, what language does according to Halliday, is its meaning-making end, which he calls 'register'. The several meanings made during language use depend on how language is structured for use, which is ‘genre’ (Halliday & Hasan, 2000). According to Halliday (1978), register accounts for the relationship between found specific situational types and the meaning choice. Nevertheless, the register does not account for the sequential organization of the field; instead, tenor and mode dynamically construct meaning in context. Tenor refers to the power and solidarity of shared values while mode refers to communicative demands of spoken and written discourse. The concept of genre provides an understanding of how people develop patterned ways of making discourse during the conversation, resulting in events with particular discourse organizational structures. A genre is “a staged, goal-oriented, purposeful activity in which speakers engage” as members of a culture (Martin, 2001, p.155). This concurs with Lemke (1990) who also identifies these patterned ways as organizational structures or activity types. This study also interrogated activity types such as triadic, learner-teacher duolog, true dialogue, external text dialogue, and cross-discussion as part of Discourse strategies. Thus, SFL provides a framework to describe the relationship between register and genre in language use.

Martin (2009) put forward a framework of analysis of discourse consistent with Halliday’s perspective about meaning that is the register variables of field, tenor, and mode across the tripartite meta-functional perspective of language use (ideational, interpersonal, and textual). Text can be interpreted by focusing on the meaning of context along three dimensions which are as follows. Ideational meaning is a resource for building field knowledge that enables people to engage in various activities whilst interpersonal meaning is a resource for valuing these activities and enacting tenor (power and solidarity about shared values) and lastly, textual meaning is a resource for phasing ideational and interpersonal meaning together in textures sensitive to mode (the communicative demands of spoken and written discourse). This study aimed to explore the teachers’ Discourse by focusing on thematics, patterns of interaction through communicative approaches, Discourse patterns, and teacher Discourse moves as well as teacher Discourse strategies. Therefore, in the next section, I present a discussion on the thematic analysis approach developed by Lemke (1990) which is underpinned by SFL. In this case, it must be noted that though I used old literature, Lemke’s work is seminal with more than 8000 citations in Google Scholar, and is still current in the sense that there are still 1300 citations since 2020. Moreover, Lemke’s work is located in science education rather than Discourse generally.

2.4.2.2 Lemke's work on language

In terms of the application of systemic functional linguistics in science education and research, Lemke's work (1982, 1983, 1989, and 1990) is notable. For Lemke (2004) the three meta-functions of language use which are ideational, interpersonal, and textual are truly semantic as proposed by Halliday. A substantial amount of work conducted by Lemke focuses on the thematic analysis of school science with particular emphasis on constructing thematic intertextual relationships construed between texts belonging to the same topic. Lemke refers to the product of such a process as a thematic pattern, which he defines as a "pattern of semantic relationships describing the thematic content of a particular topic area" (Lemke, 1990, p.12). Simply put, a thematic pattern is a network of semantic relationships among scientific concepts in a given field of study such as genetics. Like Lemke, this study considered thematic patterns constructed from thematic items and semantic relations during the teaching of basic genetics to grade 12 learners.

According to Lemke (1990) in science classroom Discourse there are two major activities performed, which are 'activity structure' producing the 'organizational pattern' of the discourse, and relationships among core concepts in the Discourse producing the 'thematic pattern' of the Discourse. A thematic pattern "shows what many different ways of saying 'the same thing' have in common. It describes a shared pattern of semantic relationships" (Lemke, 1990, p. 87). Activity structure is a "particular set of expectations about what can happen" (Lemke, 1990, p.13) in classroom discourse which is similar to the 'mode' of an interactional linguistic event according to Halliday (1978) a staged, goal-oriented, purposeful activity in which speakers engage as members of a culture. For Martin (2009) this can be construed as the 'genre' of a linguistic event that produces the 'schematic structure' of the event, which Lemke (1990) and (Gee, 1996) refer to as 'organizational structure' and 'overall discourse organization' respectively. Thus, this study among other things sought to interrogate the constructed Discourse patterns of classroom dialogue from the semantic relationships constructed during the the teaching of basic genetics to grade 12 learners (see Chapter 5 for examples)

Through a thematic analysis approach, Lemke (1982) studies science classroom talk and its context in classrooms of about 60 lessons with 20 teachers and 25 classes of pupils talking physics, biology, chemistry, geology, and astronomy in a large American city. He analyses the transcripts using thematic analysis. Furthermore, through his analyses of various series of episodes or topically related sets in the transcript of the lessons, he identified "thematic items" which are the science concepts in the Discourse (Lemke, 1990, p. 88). Special terms used in this study such as "thematic items" are defined in Table 2.2.

Table 2.2: Definition of terms used in this study

Term	Description
Science Talk	Identifies statements and/or questions from the talk turn stretch of text that specifically talks about science process and/or content
Thematics	Relationships among concepts constituting a theme
Thematic Item/s	Science concept/s in the Discourse
Thematic Development	Development of relationships that exist among core concepts in the Discourse
Locus of Thematics	Nature/type of thematics evident according to who generated the thematics e.g., Joint Thematics, student Thematics, Teacher Thematics, or External Text Thematics
Semantic Relations	Describes how the meanings of two words or phrases (thematic items) are related when they are used together in talking about a particular topic
Thematic Pattern	Way of picturing the network of relationships that exist among core concepts (described semantically, in terms of how language is used during observed lessons)
Thematic Development Strategies	Specific techniques used by teachers and learners to build up/share a new network of semantic relations (Thematic Pattern) in their classroom
Interaction Patterns	A "particular set of expectations about what can happen" in classroom Discourse
Communicative Approach	Ways in which the teacher works with the students to address the different ideas that emerge during the lesson
Discourse Pattern	Distinctive, patterns of interaction that emerge between the teacher and learners An alternative form of triadic Discourse
Teacher Discourse Moves	A deliberate action taken by the teacher to encourage, facilitate, participate in, or influence the classroom Discourse
Triadic dialogue	An activity structure of the Lesson where teachers ask questions, call on learners to answer them and evaluate the answers.
Learner-teacher duolog	A prolonged series of exchanges between the teacher and one learner.
True dialogue	An activity pattern in which the teacher and learners ask and answer one another's questions and respond to one another's comments as in normal conversation (i.e. with symmetrical status)
External text dialogue	variation on triadic dialogue, in which the teacher questions or sometimes the learner's answer is read from a written text.

Term	Description
Cross-discussion	A dialogue pattern in which learners speak directly to one another about the subject matter, and the teacher acts as a moderator or equal participant without special speaking rights
Marking importance	Teachers indicate that the current discussion has a special importance.
Marking old information	Teachers signal that the question under discussion in something the students should already know.
Marking new information	Teachers signal that new information is being presented for the first time,
Regulating difficulty	Teachers selectively pose easier or more difficult questions or directions as a means of controlling learners.
Creating mysteries	Teachers create interest in a topic by temporarily withholding full information about it, offering only hints or clues to build suspense.
Being funny	Teachers use humor in a variety of ways to encourage learners to accept their use of other control tactics.
Getting personal	Teachers make personal remarks about learners or their behaviour which may be humorous or potentially embarrassing.
Tenor	The power and solidarity of shared values
Mode	Communicative demands of spoken and written discourse
Genre	"A staged, goal-oriented, purposeful activity in which speakers engage" as members of a culture

Consequently, in this study, I conducted a thematic analysis of various episodes in the transcripts of lessons on genetics to identify thematic items or terms used to construct semantic relations as well as thematic patterns, to address my first sub-research question stated in Section 2.4.

Using the rules of semantics, Lemke (1990) identifies several forms of semantic relationships of the several thematic items used to construct thematic patterns of the lessons which give a thematic pattern when connected. Such relationships include the following, nominal, attribution transitive and circumstantial. Nominal relationships connect one thematic item with another in the form of synonyms, antonyms, hyponyms, classifiers, and locations. Attribution relationships typically relate qualities and quantities, of thematic items. Further, transitive relationships occur between various processes or activities and the objects or agents that participate in them. Furthermore, a circumstantial relation relates a thematic item to its location, time, manner, reason, material, means, and grammatical relationships of clauses, and rhetorical structures (for example, evidence/conclusion and cause/consequence). Therefore, this study sought to identify thematic items, construct semantic relations (thematic patterns) and establish thematic development strategies that teachers use to build up these semantic relations as stated in my first and third sub-research questions.

One distinctive feature of thematic analysis is its ability to 'abstract away' from the specific wordings in any particular text that constructs a specific thematic pattern (Lemke, 1990). Simply put, if two people are constructing a thematic pattern of a given text, they end up coming up with fairly the same thematic patterns. He further noted that thematic patterns in science are standardised and that during learning the process of meaning-making is the identification of the semantic relationships existing between thematic items in a given standardised thematic pattern (Lemke, 1990). In this respect, this study focused on the thematic patterns constructed by the teachers and compared some of them to the standard ones found in some course textbooks, refer to Chapter 5 for examples. In the next section, I present the strategies that teachers use to develop semantic relations and thus thematic patterns during the meaning-making process.

2.4.2.3 Teacher Discourse Strategies

Regarding the construction of semantic relations and thematic patterns, the question that Lemke (1990) would ask is: how, in a classroom, do teachers and learners use language to build up thematic patterns that correspond to the conceptual systems of a subject like science? In other words, what strategies are used to make it easier for learners to correctly infer semantic relationships from the words that are heard? How, in short, can we teach Thematic patterns in the classroom as we use them? Lemke refers to these strategies by which teachers and learners come to share a new thematic pattern in their classroom dialogue as thematic development strategies. These strategies are used in tandem with social interaction strategies and multimodal representations. These strategies are discussed further with examples in Chapter 7. In this study, I referred to thematic development strategies, social interaction strategies and multimodal representations as teacher Discourse strategies. These strategies constitute the context in which the language of science (genetics concepts) is used during the teaching of basic genetics. The teacher Discourse strategies were analysed using Lemke's Thematic analysis and particularly used to answer my third sub-research question. Like Mortimer and Scott (2003), I believe that communication is central to the aspects of Discourse such as (the language of science and teacher Discourse strategies, patterns of Discourse and teacher Discourse move). Therefore, I present communicative approaches in the next section.

2.4.3 Mortimer and Scott's Analytical Framework

2.4.3.1 Communicative Approaches

To interrogate the teachers' Discourse for the communicative approach, I was largely influenced by the work conducted by Mortimer and Scott (2003). They propose an analytical framework for understanding science classroom interactions. It is based on the observations that they made in British and Brazilian science classrooms. This framework is developed around five aspects of activities that define the role of the teacher, which are categorised into three groups concerning focus, approach, and action as shown in Figure 2.1

ASPECT OF ANALYSIS

FOCUS	1 Teaching purposes	2 Content
APPROACH	3 Communicative approach	
ACTION	4 Patterns of discourse	5 Teacher interventions

Figure 2. 1: Analytical framework for Teacher-Learner interactions
(Scott & Mortimer, 2005, p. 25)

Central to the analytical framework above is the communicative approach that the teacher adopts. The framework shows how the teacher interacts with learners by focusing their actions (teacher and learners) on the emerging patterns of Discourse and interventions as he/she focuses on the purpose or content of the lesson. According to Scott and Mortimer (2005), the teaching purpose includes opening up the problem by exploring the learners' views by introducing and developing the scientific story, as well as maintaining the developing scientific story. The content of the interaction may include the type of knowledge under discussion viz, everyday versus scientific knowledge or the language used to communicate the concepts, which may be a description, explanation, or generalisation of the concept.

The central role of the communicative approach is to show how the teacher uses several intervention strategies to shape the communication patterns to achieve the focus of the lesson. For my study, I drew from three aspects of the analytical framework; the teacher interventions and how they help shape the communicative approach and the nature of the subsequent patterns of Discourse. In my study, the teacher interventions are referred to as teacher Discourse moves and my conception of the three aspects amalgamated with Gee's Theory of Discourse, as well as Lemke's Thematic Analysis is presented later in Section 2.4.4 The concept of the communicative approach is central to Mortimer and Scott's framework since it provides a perspective on how the teacher works with learners to develop science content in the science classroom. This central feature of the framework deals with questions regarding interactions in terms of whether the teacher interacts with learners or not (Mortimer & Scott, 2003). Furthermore, the communicative approach focuses on whether the teacher considers learners' ideas in his/her teaching. Therefore, to elaborate on this aspect of the analytical framework Mortimer and Scott developed four key classes of communicative approach, which are identified by characterising the talk between teacher and learners along the two dimensions viz, dialogic–authoritative and interactive–non-interactive shown in Figure 2.2.

	Interactive	Noninteractive
Dialogic	A. Interactive /Dialogic	B. Noninteractive/dialogic
Authoritative	C. Interactive/Authoritative	D. Noninteractive/Authoritative

Figure 2. 2: Four Classes of Communicative Approach
Adopted from (Scott & Ametller, 2007)

Teachers engaging in dialogic interaction are open to different viewpoints and consider learners' ideas, interests and concerns (Calcagni & Lago, 2018) as they attend to the school science view. In other words, the teacher decentralises his/her authority by responding elaboratively to learners' contributions (Gencel et al., 2021). However, with authoritative interaction, the teachers restrict interaction to engagement with the accepted scientific view only with teachers' responses to learner contributions being evaluative (Lehesvuori et al., 2018). Figure 2.2 shows that dialogic Discourse can either be interactive or non-interactive. On one hand, a classroom can be characterised by dialogic interactions where the teacher together with his/her learners works and explores different ideas and poses genuine questions as they generate new meanings. On the other hand, the teacher may engage in a noninteractive/dialogic approach where the teacher considers different points of view, explores, and works on various perspectives. Figure 2.2 further shows that authoritative Discourse can either be interactive or non-interactive. Hence, a teacher can engage in authoritative interactions where he/she leads learners through a sequence of questions in a bid to reach a specific viewpoint. It is interesting to note that the learners' contributions are restricted to single-word answers. In contrast, a teacher may decide to engage in a noninteractive/authoritative communicative approach where the teacher presents only one point of view which is the science one and does not ask for learner participation. This study adopted the four communicative approaches discussed above and used them to probe the teachers' Discourse for emergent communicative approaches during the teaching of genetics to grade 12 learners. In addition to communicative approaches, my second sub-research question focused on patterns of Discourse and teacher Discourse moves. Hence, I present patterns of Discourse in the next section.

2.4.3.2 Patterns of Discourse

Various combinations of communicative approaches result in the patterns of Discourse that play out in the science classroom. Mortimer and Scott (2003) identified three main forms of Discourse. The first and most predominant Discourse type is the I-R-E (Mehan, 1979) where I stands for initiation (which is usually a question from the teacher), R stands for response (from learner) and, E stands for evaluation (by teacher). This I-R-E was improved by Mortimer and Scott (2003) who proposed that the E be replaced with F to form I-R-F where F stands for feedback (teacher gives feedback or elaborates on learners answer). Mortimer and Scott have shown authoritative interactions are played out through the traditional IRE/F pattern hence, the I-R-E/F triad is strongly authoritative. As Discourse evolves into dialogic, the I-R-E patterns are replaced by extended chains of utterances. These elaborated chains can be open I-R-P-R-P… or closed I-R-P-R-P…E/F. A closed I-R-P-R-P...E/F chain series is characterised by learner responses and teacher probing interventions following a single initiate move that culminates into a feedback or evaluation move by the teacher. Nonetheless, in an open chain, a series of response moves where learners respond to each other’s, or teacher’s contributions are triggered by the initiate move. These open chains do not culminate in a feedback or evaluation move. What Mortimer and Scott refer to as interventions, are referred to as teacher Discourse moves in my study which I present in the next section.

2.4.3.3 Teacher Discourse moves

According to Mortimer and Scott (2003) teacher interventions that influence patterns of Discourse include shaping ideas, selecting ideas, marking key ideas, sharing ideas; checking student understanding; and reviewing. In my study, these interventions (teacher Discourse moves) were classified into five categories viz, eliciting moves, marking moves, building moves, evaluation moves, and others which were developed from literature (Carpenter et al., 2020; Ellis et al., 2019; Khoza, 2023). In this study, I defined teacher Discourse moves as actions that teachers can plan carefully and use to open up the classroom Discourse. During analysis, I regarded teacher Discourse moves as specific turns of teacher talk that are used to promote learner talk and achieve certain instructional goals (Windschitl et al., 2020). In my study, shaping ideas was classified as eliciting moves, selecting ideas into selecting moves, marking ideas into marking moves, checking student understanding into building moves and reviewing interventions were not considered in my study. Having looked at the various aspects of Discourse considered in this study, I, therefore present my Theoretical Framework in the next section.

2.4.4 My Theoretical Framework

As researchers, we want others in our academic community to see the research phenomenon that we are studying. Thus, we need a representation, or a vehicle such as the use of the term 'lens' to negotiate our interpretation of this phenomenon with others (Ojansivu et al., 2022). To accomplish this, I adopted Gee's Theory of D/discourse as the overarching theory for exploring the teachers' use of the language of science in their contexts. To do this, I drew mainly from two frameworks for analysing the teachers' Discourse. On the one hand, based on my first and third sub-research questions, I drew from Lemke's Discourse analysis approach known as Thematic Analysis for analysing the language part of the teachers' Discourse and teacher Discourse strategies, which constitute the context. On the other hand, I drew from Mortimer and Scott's Communicative approaches and Discourse patterns as well as interventions (moves) for analysing the interaction patterns and teacher Discourse moves as stated in my second sub-research question.

2.4.4.1 Linking theory to my sub-research questions

Since the objective of this study was to characterise the teachers' Discourse when teaching basic genetics, the overarching theory was Gee's Theory of D/discourse. Thus, analysis was done in terms of language (genetics content) and context. My first sub-research question was intended to establish how teachers develop genetics concepts during the teaching of basic genetics to grade 12 learners. With this, I sought to understand how teachers use the language of science (genetics content) in their classrooms using three aspects of language viz, types of thematics, thematic items, semantic relation, and thematic patterns shown in Figure 2.3. Therefore, my study focused on these four aspects. The first aspect of language that I focused on speaks to the types of thematics constructed in the science classroom which can be teacher thematics, joint thematics, or learner thematics. According to Lemke (1990), teacher thematics are semantic relations/thematic patterns constructed by the teacher on his/her own while joint thematics are constructed by the teacher together with his/her learners. Learner thematics are semantic relations constructed by learners on their own. The second aspect of language that I considered for analysis refers to thematic items which are the science terms that teachers use as they construct semantic relations or thematic patterns such as *DNA, allele,* and *gene.* The fourth aspect of language that I considered for analysis relates to the semantic relations or thematic patterns which are the types of semantic relations such as *Item/Elaboration* and *Agent/Process*. Semantic relations combination of semantic relations would result in thematic patterns.

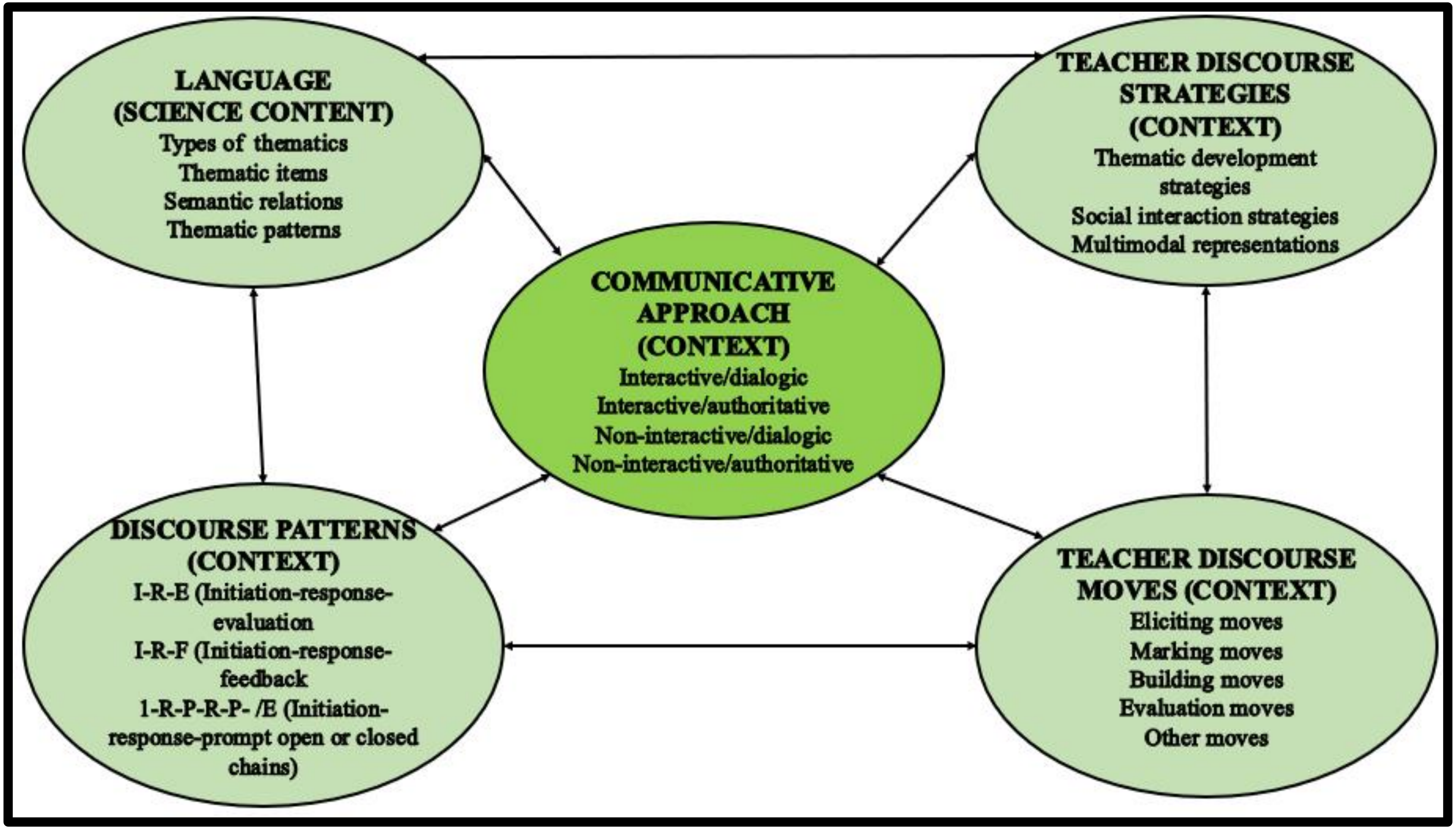

Figure 2. 3: My Theoretical Framework

My analysis for this sub-research question was guided largely by Lemke's Thematic Analysis (refer to data processing and analysis procedures in Chapter 4).

My second sub-research question sought to explore the interaction patterns and teacher Discourse moves that are evident during the teaching of genetics to grade 12 learners. To accomplish this, like Mortimer and Scott (2003), I considered the communicative approach to be at the heart of Discourse as shown in Figure 2.3 where it links with all aspects of Discourse. So, to address my second sub-research question, I identified three aspects of Discourse which are communicative approaches, patterns of Discourse and teacher Discourse moves that are evident in the four teachers' classrooms. These three aspects constituted the context part of the teachers' Discourse. Firstly, in terms of communicative approaches, I sought to understand the communicative approaches that teachers adopt to guide the talk to develop genetics concepts in their classrooms. I did this by determining whether interactive/dialogic, interactive/authoritative, non-interactive/dialogic, or non-interactive/authoritative approaches prevail. Secondly, in terms of patterns of Discourse, I identified patterns of Discourse that emerge during science talk and determine whether I-R-E/F (Initiation-Response-Evaluation/Feedback) triads prevail or whether there is evidence of 1-R-P-R-P-/E (Initiation-Response-Prompt open or closed chains) shown in Figure 2.3. Lastly, to analyse the data for teacher Discourse moves, I identified the teacher Discourse moves that prevail in terms of whether they are eliciting, marking, building, evaluation, or other moves as presented in Figure 2.3. My data analysis for this sub-research question was guided largely by Mortimer and Scott's communicative approaches, patterns of Discourse, and teacher interventions which I referred to as moves. (See discussion of the data processing and analysis procedures in Chapter 4)

Through my third sub-research question concerned with teacher Discourse strategies, I sought to understand the strategies used by teachers to make it easier for learners to correctly infer semantic relationships from the words that are heard. In other words, how we can teach thematic patterns in the science classroom? Lemke (1990) refers to these strategies by which teachers and learners come to share semantic relations and thus, a new thematic pattern in their classroom dialogue as thematic development strategies. To answer my third sub-research question, identified the emerging teacher Discourse strategies by constructing 'maps' per teacher for each of the three strategy categories viz, thematic development strategies, strategies for interaction, and multimodal representation presented in Figure 2.3. These teacher Discourse strategies constitute the context part of the teachers' Discourse. My data analysis for the third sub-research question was guided largely by Lemke's Thematic Analysis (refer to data processing and analysis procedures in Chapter 4). The double arrows in the diagram representing my theoretical framework show that the five aspects of the teachers' Discourse that I focused on in this study influence and shape each other.

2.5 Life Sciences CAPS document, Examination Guidelines and ATP

In South Africa grade 12 life sciences teachers have access to three important documents viz, the National Curriculum Statement (NCS) Curriculum and Assessment Policy Statement (CAPS) for life sciences and the Examination Guidelines and the Annual Teaching Plan (ATP). Refer to https://www.education.gov.za for these documents.

2.5.1 Life Sciences CAPS document

One of the aims of the CAPS document is to ensure that children acquire and apply knowledge as well as skills in ways that are meaningful to their own lives (DBE, 2011). The CAPS document provides a clear list of what learners are expected to do and links the concepts to what learners would have done before. In particular, it provides the duration of time to be spent on a specific topic or content and prescribes investigations to be conducted as well as resources that can be used. Like the examination guidelines and ATP documents, the CAPS document outlines the topics according to papers 1 and 2 as well as mark allocations. Despite being dropped from the ATP and Examination Guidelines due to COVID-19, the topic 'Human impact on the environment' still appears in the CAPS document. This is because the CAPS document has remained unchanged since 2011, see DBE (2011). The cutting down of content is apparent in the ATP and Examination Guidelines. Even after 2020, the topic of 'human impact' is not yet back which is another interesting thing. It looks like the most important socially relevant topic has been scrapped leaving the academic topics. This shows that the government's priority is by no means to create relevance for science in the world. So, the teachers end up teaching a decontextualised curriculum. Furthermore, like the Examination guidelines and ATP, the CAPS document outlines the cognitive levels and the degrees of difficulty for examinations and test questions.

2.5.2 Life Sciences Examination Guidelines, past examination papers and marking guidelines

The Examination Guidelines document serves two purposes. The first one is to provide clarity on the depth and scope of the content to be assessed in the grade 12 National Senior Certificate (NSC) Examination in life sciences, the second one is to assist teachers in adequately preparing learners for the NSC Examinations (DBE, 2021a). Also, this remains unchanged since 2021 (which incidentally was in the midst of the COVID-19 pandemic). It is underpinned by the CAPS document and is meant to articulate the aspirations adopted by the CAPS document. Hence, it should not be used as a substitute for the CAPS document from which teachers are expected to teach. In addition, the examination guidelines are purely grade 12 focused and list topics to be included from earlier grades. Like the CAPS document, it presents a recommended sequence for teaching the nine topics starting from 'DNA: The code for life' and ending with 'Evolution' and elaborates further on the actual content that the learners will be assessed on in the final examination. The Examination Guidelines document further presents final examination topics in terms of Paper 1 and Paper 2 as well as mark allocation for each topic. Before the onset of COVID-19, the distribution of genetics questions in Paper 2 of the final examination was 45 out of 150 marks (30%). This has since changed to 48 out of 150 marks constituting 32% of the final Paper 2 examination which implies that the genetics topic has increased in importance. In addition to Examination Guidelines, the actual past examination papers and examination marking guidelines communicate what will be tested at the end of the year. The ATP as discussed earlier provides for content sequencing and timeframes.

2.5.3 The Annual Teaching Plan (ATP)

This document is used as a pacesetter for grade 12 life sciences teachers providing sequencing and timeframes in which the concepts are expected to be covered. It also provides a list of topics to be taught according to the CAPS document as well as core concepts, skills, and values. The ATP also highlights the requisite pre-knowledge and prescribes resources as well as formal and informal assessments (DBE, 2023). This document has been altered from year to year and has versions for grades 10 and 11.

2.6 Chapter Summary

In this section of the literature review, I have highlighted that the teaching of genetics is a difficult process which in turn makes it difficult for students to grasp the basic genetics concepts. There is a lack of conceptual frameworks that probe the teachers' classroom Discourse while considering the centrality of communicative approaches. Thus, I developed an analytical framework for investigating how the teacher through a selected communicative approach develops science content/concepts using I-R-E/F or closed or open long chain (I-R-P-R-P) Discourse patterns. I also considered the teacher Discourse moves, the teacher Discourse strategies, social interaction strategies and multimodal representations employed by the teachers as they constructed the genetics concepts with grade 12 learners. I also highlighted that much research on classroom Discourse has overlooked the important aspect of classroom Discourse which is the construction of knowledge. Hence, there is an opportunity to examine the construction of genetics concepts through the teachers' Discourse while considering the centrality of communicative approaches and the current study did exactly that. Ultimately, there is a need to curb the dearth of research on classroom Discourse concerning knowledge construction. The theories and research from the literature reviewed here form the framework for the analysis of language (genetics content/concepts) used by life sciences teachers in their observed classrooms (context) which constitute Discourse and the discussion of my research findings, presented in the chapters that follow.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.0 Introduction

This chapter provides a comprehensive description of the research design and methodology employed in this study to answer the sub-research questions presented in Chapter One. These sub-research questions are reiterated in this section for ease of reference. This study was guided by the following main research question: *What characterises teacher's Discourse during the teaching of genetics in South African classrooms?* This question was further divided into sub-research questions which are:

1. *How do teachers develop genetics concepts during the teaching of basic genetics to grade12 learners?*
2. *What forms of interaction patterns and teacher Discourse moves are evident during the teaching of basic genetics to grade 12 learners?*
3. *What kinds of emergent teacher Discourse strategies can be extracted from the teaching of basic genetics to grade 12 learners?*

This study is about the teachers' use of language in their classroom contexts which is referred to as Discourse with an uppercase or big 'D' (Lemke, 1990). The language of focus in this study is not the language of instruction but the language of science used by teachers during the teaching of the topic of genetics to grade 12 learners. To accomplish this, I adopted a case study design following interpretivist traditions to study four life sciences teachers as they taught basic genetics to grade 12 learners. To collect the data[2] for this study, the research instruments I used were classroom observations, semi-structured interviews, and field notes. In the proceeding sections, I start by providing a brief discussion of the interpretivist paradigm, which underpins my study and provide further details and justifications for the choice of my methodology, and data collection methods. I also consider some challenges, ethical and trustworthiness issues.

[2] There is controversy between the use of the word 'data' as plural (are) or singular (is). In this study I use the word 'data' as singular

3.1 Research Design

A paradigm is a foundational perspective espoused with a set of assumptions guiding the research process (Leavy, 2022). In other words, a research paradigm guides the researcher throughout the research process, from setting the purpose of the research to the formulation of the research questions, selection of the participants, selection of data collection instruments, analysis of data, and presentation of findings (Kivunja & Kuyini, 2017). The Education research literature has discussed many theoretical paradigms nonetheless they can be reduced to three main strands viz., positivist (and post-positivist), interpretivist/constructivist and critical theory (Blaikie & Priest, 2017). For Merriam and Tisdell (2015), positivist researchers consider knowledge and perceptions of the world to be hard, real, and transmittable in a tangible manner while interpretivist researchers regard knowledge to be softer, subjective, and influenced by experience. Merriam and Tisdell (2015) further argue that for positivists, knowledge cannot exist beyond what is objectively observable while interpretivists perceive knowledge as originating in the individual's mind. Owing to this, positivists generally use quantitative methods while interpretivists use qualitative procedures for data collection and analysis. Lastly, the critical theory research paradigm emphasises human interactions and is based on the assumption that power inequality shapes all ideas and social interactions (Howell, 2016). It considers values and ideas shaped by gender, ethnic, social, economic, cultural, and political experiences, and the aim of research is to contribute to knowledge and transform societies.

My study was concerned with teachers' Discourse (use of science language in context) during the teaching of basic genetics to grade 12 learners. Local research on classroom Discourse has largely used an interpretivist approach which is also known as a constructivist approach through case studies (Khoza, 2023; Mavuru & Ramnarain, 2020; Msimanga, 2021; Probyn, 2015). Unlike the positivist approach whose methods can miss special features that help researchers to understand a situation (Merriam & Tisdell, 2015), the interpretivist approach seemed to be more appropriate for my study which investigates how life science teachers use the language of science in their contexts (Discourse). This is because the interpretivist philosophies allow researchers to study people's experiences by providing in-depth understanding and detailed descriptions of unique individual experiences rather than claiming generalisability through quantitative data collection methods (Hancock et al., 2021). Therefore, in this study, I examined teachers' experiences through interpretivist philosophies to provide more detailed descriptions and an in-depth understanding of their unique lived experiences in the classroom instead of claiming generalisability. I intended to understand the social phenomena under investigation which was teachers' Discourse through the participants' (teachers and learners) perspective within their classroom contexts. This endeavour required a qualitative approach to inquiry rather than a quantitative one. To a certain extent, my positionality (refer to Section 1.6 in Chapter 1) as a science teacher has been influenced by the positivism in natural science. Nonetheless, I believe that teaching and learning in classrooms are products of personal experiences, and each individual's teaching and learning experience is unique. Therefore, to conduct this study, I adopted the interpretivist approach.

When conducting research one can adopt mixed, quantitative, or qualitative approaches for data collection and analysis (Queirós et al., 2017). Mixed methods research is an approach employed in social, behavioural, and health sciences where the researcher collects both quantitative and qualitative data, combines the two sets, and then makes some interpretations based on the strengths of the two data sets to understand a given research problem (Creswell, 2015). On the one hand, quantitative research procedures, place much emphasis on objectivity when measuring and describing phenomena which are maximized by the use of numbers, statistics, and control (Leavy, 2022). On the other hand, qualitative research procedures emphasize the necessity for studying phenomena in their natural settings as one attempts to make sense of or interpret phenomena in terms of the meanings they are given by people (Merriam & Tisdell, 2015). They further argue that the major concern when conducting qualitative research is understanding the phenomenon in question from the participant's view rather than the researcher's. Most of the data collected in a qualitative study is richly descriptive and in the form of words rather than numbers obtained when using quantitative procedures and may vary according to the observer (Merriam & Tisdell, 2015). This study is purely in the qualitative domain, so it has a constructivist epistemology. Therefore, this study adopted an interpretivist design which makes use of qualitative procedures for collecting and analysing data. As an emerging qualitative researcher, I believe that activities can only be understood better in their natural settings. Owing to this, I went directly to a particular setting of my interest which is the school (classroom), and collected data through direct classroom observations, interviews, and field notes. There are many types of qualitative research, one of them is the case study approach which I discuss below

3.2 The Case Study Approach

A case study is an in-depth exploration of a single entity and what is being investigated becomes the case which can be an activity, process, event, or individual (Hancock et al., 2021). Though a case study may be criticized for lack of generalizability, Yin (2018) argues that insights obtained from a case study may impact policy, procedures and research. A case study approach was adopted for this study because it enabled me to closely observe life sciences teachers as they taught grade 12 learners basic genetics concepts in their specific contexts. This approach was appropriate for my study because it allowed me to obtain detailed accounts of how life sciences teachers use the science language in their contexts (Discourse) when teaching basic genetics to grade 12 learners. The case study approach is holistic because it is conducted in a real-life context instead of relying on the participants only (Hancock et al., 2021). In this study, a case study allowed me to use various methods like direct classroom observations, field notes and interviews to collect data about life sciences teachers' use of science language when teaching basic genetics in their classrooms. I did not rely on what the teachers had to say during interviews only but also sat down in their classrooms and observed them as they taught basic genetics.

As prominent seminal researchers and research methodologists in the field of case study, Robert Yin, Sharan Merriam, and Robert Stake hold their epistemic commitments that influence their perspectives on case study methodology and the principles and the steps they suggest researchers apply while adopting the case study method in their research (Yazan, 2015). Yin reveals positivistic tendencies in his perspectives on case studies which are associated with objectivity, validity, and generalizability while a constructivist orientation underlies Stake's perspective on case study research (Yazan, 2015). In other words, Stake perceives qualitative case study researchers as interpreters, and gatherers of interpretations who report their construction of the knowledge that they obtain through their investigation. Merriam's perspective on the case study is consistent with Stake's in the sense that she believes that constructivism should be the epistemology-orienting qualitative case study (Yazan, 2015). Thus, for Merriam, qualitative case study researchers strive to understand the meanings of knowledge constructed by people in own their settings.

As an emerging educational researcher, epistemologically I closely subscribe to the constructivist paradigm because I believe that knowledge and meanings are actively and jointly constructed by individuals (Amineh & Asl, 2015). Owing to this philosophical stance, I found myself positioned epistemologically consistent with Merriam and Stake than Yin. Therefore, when choosing the type of case study appropriate for my study, I was influenced more by Stake, whose view of case study design is underpinned by constructivist epistemologies. As an interpretivist, I adopted qualitative case study procedures in this study for collecting and analysing data. According to Sutton and Austin (2015), qualitative research investigates the quality of relationships, activities, situations, or materials. In qualitative research, the natural setting is the direct source of data and the researchers are more important than the research instruments. Researchers using this approach believe that activities can best be understood in the settings in which they occur (Leavy, 2022). So, researchers go directly to a natural setting of interest like a school to collect data through observation and interviews. In this case, the researcher can use a pen and paper or audio or videotaping equipment to record the data. In addition, qualitative data is collected in the form of words or pictures rather than numbers as in quantitative research. The kinds of data collected in qualitative research include observation and interview transcripts, field notes photographs, audio recordings, videotapes, dairies, personal comments, memos, official records, or anything else that may communicate the actual words or actions of people (Leavy, 2022). Hence, participants' assumptions, motives, reasons, goals, and values are likely to be the focus of the researchers' questions (Sutton & Austin, 2015).

In this study, I adopted a qualitative case study research design because I sought to gather information about certain characteristics of life sciences teachers regarding their science language. In particular, I probed life sciences teachers' practices in terms of how they developed genetics concepts, the interaction patterns and Discourse strategies they employed during the teaching of basic genetics to grade 12 learners. Hence, I visited the life sciences classrooms and observed teachers as they taught genetics to establish how they developed genetics concepts, the interaction patterns and moves and the Discourse strategies they used when teaching their learners basic genetics concepts. I then conducted a follow-up interview with each teacher to check and verify language issues that arose from the classroom observations and the reasoning behind their actions. In other words, I used the interviews for triangulation (Flick, 2018). So, my case consisted of the four life sciences teachers who provided an in-depth understanding of the teachers' use of science language when teaching basic genetics in science classrooms. I observed life sciences teachers teaching basic genetics to contribute towards the effective teaching of genetics in South African classrooms. In the next section, I present the research instruments adopted in this study.

3.3 My Research Design

This study was about teachers' Discourse focusing on teachers' use of science language in their contexts (classrooms). The following were key considerations in my research design that were derived from my research questions:

- Investigating the content in terms of thematics constructed, thematic items, semantic relations/thematic patterns.
- Examining the interaction patterns in terms of communicative approaches, Discourse patterns, and teacher Discourse moves.
- Probing the teachers' practices for emerging Discourse strategies

In this section, I justify my choice of research sites, selection of the participants and choice of research instruments adopted in this study.

3.3.1 Background of teachers and schools in South Africa

In South Africa the Schools Act No. 84 of 1996 provides for two types of schools which are public and independent (UNESCO, 2010) where public schools are governed and supported by the state and the majority of the teachers are employed in the public schools (UNESCO, 2010). The Policy on Minimum Requirements for Teacher Education Qualifications (MRTEQ) shows that Universities' Initial Teacher Education (ITE) programmes are also governed by government policy. They produce teachers with either a four-year Bachelor of Education (BEd) degree or a one-year Post Graduate Certificate in Education (PGCE) after completing a three-year undergraduate degree (DHET, 2011). The two types of teachers produced hold a four-year qualification in teaching. Hence, the current official qualification requirement for a teacher in South Africa is M+4 which means a (school-leaving) matric certificate plus four years of initial teacher education. The previous official teaching requirement was M+3 meaning matric plus three years of initial teacher education receiving either a certificate or diploma. Thus, currently, most teachers in South Africa are qualified with M+3. When going through training the teachers are allowed to choose the phase they would like to teach viz, Foundation, Intermediate, Senior, and Further Education Training (FET). Hence, there are very few M+3 teachers are left in the system since most have upgraded to **Advanced Certificate in Education (ACE)** which in turn upgrades them to M+4/REQV 14 from M+3/REQV 13.

Some universities allow a combination of two phases. Nonetheless, for the Intermediate, Senior and FET phases, the student teachers are allowed to choose subjects for specialisation in fields such as languages, mathematics, the sciences, technology, the humanities, and business management (DBE, 2012). When it comes to teaching in South Africa, all teachers are expected to be registered with the South African Council for Educators (SACE). For SACE registration, professionally qualified teachers are required to have professional teaching qualifications such as a B.Ed., PGCE, NPDE, or Diploma in grade R teaching are required for registration. In South Africa, it is a requirement that all teachers teaching in public schools teach the same content from a common curriculum (DBE, 2011) to all learners. Therefore, either M+3 or M+4 teachers were considered for participation in this study as both are qualified. In addition, the extent of teachers' experiences in teaching life sciences was not considered for this study. Nonetheless, in this study participants were selected because they were teaching grade 12 life sciences at public high schools during the time of my study. Next, I present the population and sampling method for the study.

3.3.2 Population and Sampling

The process of identifying individuals for participation in research is known as sampling and the selected sample is meant to represent the population to which the researcher intends to apply the findings (Dhivyadeepa, 2015). Nonetheless, the process of sampling in qualitative is different from quantitative. Four life sciences teachers who were teaching grade 12 at three public schools in Johannesburg constituted the sample for this study. On the one hand, the sampling method used for selecting these teachers was purposive about the class level they were teaching that year. Purposive sampling is a process whereby researchers select particular individuals from a population that will be representative regarding the topic of interest (Obilor, 2023). Hence, researchers use the knowledge about the population to make their judgments to select participants that will provide the best information for them to address the aim of the study. On the other hand, the sampling method used in this study was convenience sampling to some extent as the teacher teachers were all teaching in government schools in a certain part of Johannesburg which was close to me. A convenience sample is drawn from a population because it is conveniently accessible to the researcher (Andrade, 2021). Thus, in my study sampling involved a combination of both purposive and convenience sampling methods.

In this study, learners taught by the selected teachers automatically participated in the classroom observations. The advantage of using the purposive sampling method is that it is less costly and time-consuming. It is also easy to administer, usually assures a high participation rate, receipt of needed information and generalisation is possible to similar participants (Obilor, 2023). However, the purposive sampling method is known for being less representative of the identified population and difficult to generalise to other participants (Obilor, 2023). Since this study focused on the life sciences teachers' use of language in South African classrooms when teaching genetics, there was no option for me to choose one level from the various FET grades because the CAPS Curriculum only offers genetics at grade 12. As alluded to earlier in Chapter 1, the Diagnostic Reports for the years 2017-2021 show that learners do not perform well in the topic of *genetics* because some teachers are not confident to teach it. It is against this backdrop that I selected grade 12 teachers for participation in this study. Moreover, in South Africa, grade 12 determines the number of learners enrolling for tertiary education to train in life sciences and science-related careers. Next, I present the sample details.

3.3.3 Sample Details

3.3.3.1 The three participating schools

The three schools that participated in this study are located in neighbouring Johannesburg suburbs in Gauteng province. At this point, I need to make a disclosure that I am teaching at one of these schools. Teaching at this school made it easier for me to get permission from teachers for me to watch them while they taught. Nonetheless, to mitigate the coercion of teacher participants, I obtained informed consent and documented it in a written form and gave them the information letter which provided them with clear and concise information about my purpose, and scope. methods, data collection, data protection, and data usage. Two of the participating secondary schools are public coeducational secondary while the other one is a boys-only secondary school. According to Flick (2022), research data need to be protected, and any references to the research participants must be based on the use of pseudonyms. Owing to this, the participating schools were allocated pseudonyms which are School A, School B, and School C. Schools B and C did not have boarding facilities whilst School A had boarding facilities which accommodated four hundred learners though it boarded only 76 at the time of this study. All three schools were fee-paying, although School A was more expensive than Schools B and C. Further, all three were Quintile 5[3] schools/suburban that expected school fees to be paid over twelve months because they received only R204 per learner per year from the

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[3] Quintlie 4-5 Fee paying schools
Quintile 1-3 No fee paying schools

government. Their fees ranged between R20 000 and R30 000. School A had an enrolment of 1254 while School B and School C had 1324 and 542 respectively. (N.B: these are the total numbers of learners who attended school at these participating schools)

The three schools used the CAPS curriculum and offered it to grades 8 to 12. Both School A and School B had three grade 12 life sciences teachers while School C had only one life sciences teacher since their enrollment was small. In terms of physical appearance, School A boasted a welcoming environment with well-maintained buildings, gardens, and sports fields which were perfect for rugby, cricket, athletics, hockey, and netball. The other two schools had good infrastructure which was going down slowly due to poor maintenance. In the next section, I will present details about the four participant teachers.

3.3.3.2 Summary of the four participating teachers' profiles

The first participant teacher is Mrs. Durand, a female life sciences teacher who was also the head of department (HOD) for life sciences and natural sciences at the School A where she had been teaching life sciences for twenty-seven years at the time the study was conducted. The second participant teacher is Mr Zindi, a male life sciences teacher who was teaching life sciences, natural sciences, and technology also at School A and had been teaching life Sciences for twenty-eight years. The third participant is Mrs. Letsiba, a female life sciences teacher who was also the head of department (HOD) for life sciences only at School B had been teaching life sciences for over twenty-five years at the time this research was conducted. The fourth participant is Mr. Zulu, a male South African life sciences teacher who was teaching life sciences and natural science at School C and had been teaching life sciences for seven years at the time the research was conducted. All three participating schools were quintile 5 schools. Table 3.1 provides more information about the participating schools and teachers.

Table 3. 1: Teacher profiles and research context

Teacher Pseudonyms	**Mrs. Durand**	**Mr. Zindi**	**Mrs. Letsiba**	**Mr. Zulu**
Gender	Female	Male	Female	Male
Race	White South African	Black Zimbabwean	Black South African	Black South African
Home language	Afrikaans	Shona	Setswana	IsiZulu
School	A	A	B	C
Gender of learners	Males and Females	Males and Females	Males and Females	Males only

Teacher Pseudonyms	Mrs. Durand	Mr. Zindi	Mrs. Letsiba	Mr. Zulu
Grades taught	10, 11 & 12	11 & 12	12	12
Number of learners	25	33	21	21
HOD/Teacher	HOD	Teacher	HOD	Teacher
Qualifications	Bachelor of Education degree in Zoology: Wits Postgraduate Diploma in Education: Wits	Bachelor of Education degree in Biology- Cuba	Higher Diploma in Education Vista University and Matthew Goniwe School of Leadership and Governance for Leadership and Management	Bachelor of Education: Wits
Teaching Experience	27	28	25	7
NSC marking Experience	2	1	10	2

3.3.4 My Data Collection Process

Gaining access

3.3.4.1 Ethics considerations

Ethics deal with beliefs about what is considered to be wrong or right, proper, or improper, and good or bad (Merriam & Tisdell, 2015) when conducting research. In this study, I considered ethics since the focus of my study was on people. I did this by applying for ethics clearance from the Ethics Committee at the University of the Witwatersrand and my protocol number was H19/07/43 (see Appendix A1). In addition, I sought permission from the Gauteng Department of Education (GDE) to conduct my study in three selected public secondary schools in Johannesburg. I did this by completing a GDE request form and attaching the following documents: a copy of my research proposal, observation and interview schedules, information sheets (for principals, SGB chairs, teachers, and learners) as well as consent forms for both teachers and learners. Permission was granted by the GDE (see Appendix A2 for the GDE approval letter).

To gain access to the three participating schools, I also sought permission from each of the principals and School Governing Body (SGB) chairs by giving them the information letters and explaining the objectives of my study. The three principals permitted me to conduct the study at their schools. Then, I invited the selected teachers and learners to participate in the study by issuing them with teachers' and learners' information sheets as well as consent forms (see Appendix A3, Appendix A4, Appendix A5, Appendix A6, Appendix A7, and Appendix A8).

These consent forms sought permission for participation, video, and audio recording during the study. Through the information letters, I informed the potential respondents of the goals of the study and what I hoped to achieve. In addition, through the information letters, I assured the potential respondents that their participation was free and that they had a right to withdraw their participation from the research at any time. Thus, in this study, I adhered to the key theme of principles and practices of research ethics which states that participation in a study should be based on informed consent meaning the participants know and understand the risks and benefits of their participation (Flick, 2022).

I only engaged the participants in the study after obtaining permission from them through consent forms not verbally. During the study, I was always open and honest with the participants and never misled them. To address issues of anonymity and confidentiality, I made sure that there was no link of names or identities to the research findings through pseudonymization (Flick, 2022). Particularly, I retained the anonymity of the participants and schools by using pseudonyms. Generally, in this study, I adhered to the ethical considerations of the Faculty of Education, University of Witwatersrand.

3.3.4.2 Preparation for data collection

After obtaining consent from the four teachers and hundred learners that participated in this study, I asked the teachers for copies of their timetables. I then asked them to choose the classes that they wanted to participate in the study so that I would know the time to visit each participant. The topic of genetics is usually taught during the second term. In qualitative studies, the researcher is considered the primary instrument for data collection and analysis (Merriam & Tisdell, 2015). Thus, during data collection, a researcher can assume one of the following roles during classroom observations viz, complete participant, participant-as-observer, observer-as-participant and complete observer (Yin, 2015).

According to Merriam and Tisdell (2015) when researchers assume the role of complete participant, they interact with the participants and their identities may not be known by the participants. On the contrary, researchers who take on the role of participant-as-observer participate fully in the group's activities but make it clear to the group that they are conducting research. Researchers who choose the role of observer as participant make their role very clear by not pretending to be members of the group though they may participate a little in the group's activities. Lastly, researchers who assume the role of complete observer are detached from the group as they only observe the activities of the group without participating. The four roles have their strengths and weaknesses. A complete participant is likely to get a true picture of the group's activities whilst a complete observer is likely to have the least effect on the action of the group under study. Participant-as-observer and the observer-as-participant are both likely to focus their attention on the researcher's activities instead of the normal group's routine.

In my study, I sought to understand the teachers' use of the science language as they taught genetics in their classrooms (Discourse). Particularly, I wanted to understand the Discourse from the teachers' perspective not my own. Owing to this, as a researcher, I decided to assume a complete non-participant role during the classroom observation process. My role as a non-participant complete observer allowed me to conduct the observations with minimal effect on the teacher and class activities.

While waiting for the right time to collect data, I had to make a final decision about the observation tool, in terms of the specific concerns that needed to be included. I also used the waiting time to look for audio and video recording instruments since I was supposed to video record the lessons and audio record the interviews. To test my instruments, I conducted a pilot study with a female colleague who was teaching grade 10 life sciences at my school and was not going to be part of the actual research sample. Finally, I sought permission from my principal to visit the participating schools for data collection. My principal gave me permission on condition that my classes were attended to by a colleague.

3.3.5 My Pilot Study

In this study, I opted to use qualitative research methods for collecting data which are classroom observations and post-classroom interviews. To conduct these two data collection methods, I decided to video record the classroom observations and audio record the post-classroom interviews. Therefore, I conducted a pilot study to check the feasibility of the classroom observation tool and the interview schedule. Further, I intended to test the recording devices that I intended to use for data collection. I used a professional camera, a tablet, and a smartphone. I used three devices instead of just the camera to capture all the conversations clearly and to make sure that I backed up information in case something went wrong with any one of them. I also conducted the pilot study to determine roughly the amount of time that would be required for each interview session to plan accordingly. Before conducting the pilot study, I sought permission from the teacher to use consent forms and learners to use information sheets and assent forms (see Appendix A11 for the assent form). Since these learners were under eighteen years old, I also sought permission from their parents or guardians through information sheets and parent/guardian consent forms. It is important to note that I translated the parents' letters to IsiZulu and Setswana to cater for parents who might not understand English (see Appendix A15, Appendix A16, Appendix A17, Appendix A18, Appendix A19, and Appendix A20 for the translated documents). Thus, parents or guardians received a letter to explain the nature of the study and filled in consent forms for their children's/wards' participation in the study and to be video-recorded. Copies of the letters and consent forms that the parents/guardians received from me are presented in Appendix A. In this study, informed consent was obtained from teachers, learners, and their parents or guardians. Thus, when conducting the pilot study, I also adhered to the ethics principles and guidelines (Flick, 2022). I only conducted the pilot study when all consent forms from parents and assent from learners were signed.

Once consent and assent were obtained from concerned parties for the pilot study, I conducted the pilot study. This pilot study was conducted in two parts. Firstly, I conducted a classroom observation with the selected life sciences teacher, a lady who was introducing the topic of the circulatory system to grade 10 learners. I conducted the classroom observation while recording with the three recording devices, using the observation schedule for taking some field notes. As a researcher, I wanted to establish roughly the kind of teacher's Discourse to expect during the actual classroom observations. This teacher was from School A and was not part of the research sample. During the classroom observation, she used PowerPoint with images representing words that were listed on the PowerPoint slide as important.

To perform coding for the pilot study, I used the coding scheme presented in Table 4.3 which I developed by amalgamating Mortimer and Scott's Communicative Approaches, patterns of Discourse and teacher interventions (teacher Discourse moves). I coded manually (at this stage I did not know how to use ATLAS.ti) for the locus of thematic development, thematic items, semantic relations (thematic patterns), and the thematic development strategies used by the teacher. I also coded the for communicative approaches, patterns of Discourse and teacher Discourse moves as well as other strategies employed by the teacher during the observed lesson. For the detailed coding process refer to section 4.6.3.

The PowerPoint was used in conjunction with the chalkboard where she made some drawings during the lesson. Her thematics were mainly teacher thematics where she constructed semantic relations and thus thematic patterns on her own without asking for learner participation. Some

of the thematic items used by this teacher to construct semantic relations are *bicuspid*, *inferior vena cava*, *superior vena cava*, as well as *systemic and pulmonary circuits*. The predominant semantic relation in this teacher's classroom was Item/Elaboration. During the lesson, she was mostly engaged in an authoritative noninteractive approach and the Discourse pattern was mostly I-R-E whenever she included learner participation in her discussions. Since the patterns of Discourse evident in her classroom was I-R-E the teacher's Discourse moves were the eliciting type used where she elicited information from learners, refer to Chapter 6 for more information. There was no evidence of building type of moves. The predominant type of thematic strategy was **logical exposition** where in a monologue, the teacher exposed her learners to the biology concepts in question. In cases where there was dialogue, the teacher used the **teacher question series** where simple one-word answer questions were posed by the teacher. In terms of thematic control strategies, the teacher **marked** the **importance** of the terminology and **marked new information**. **Controlling pacing** and **signalling boundaries** were the structural control strategies that were employed by the teacher. As alluded to earlier, the teacher used visual representations in the form of images and notes on the slides on PowerPoint as well as gestures.
After the classroom observation, I watched the video and adjusted the questions in the interview schedule based on the language issues that arose from the classroom observation. Here, I wanted to test the feasibility of the interview schedule and to establish the amount of time that would be required for the actual interviews with the participants. Moreover, this part of the pilot study was meant to also test the audio recording instruments.

During the pilot study, I encountered two challenges. Firstly, the recorded audio was inaudible. So, I considered locating the recorders in the front, close to the participant teachers to capture the teachers' utterances. The second challenge was that, while I was watching the video recordings one of the devices stopped playing because the cells became flat. I then decided to use new batteries when starting a new recording when conducting the actual classroom observations. Overall, the pilot study assisted me in perfecting my classroom observation tool and interview schedule. Moreover, the pilot helped me to check the technical details and my ability to see and hear for coding purposes.

3.3.6 Classroom Observations

Observations are conducted in the setting where the phenomenon of interest naturally occurs (Merriam & Tisdell, 2015). In this study, the phenomenon I sought to understand was the teachers' Discourse which naturally occurs in the classroom setting. Hence, classroom observation was the most appropriate instrument for collecting data about the teachers' Discourse as they taught basic genetics to their grade 12 learners. To record the classroom observations, I used a video recorder. During the classroom observations, I used an observation tool (Appendix A15) to take field notes. Field notes are a written account of the observation (Merriam & Tisdell, 2015), an example of an extract of my field notes is provided in Chapter 4 Section 4.2.3. My observation tool addressed seven concerns that were derived from my research questions. In this study, I assumed the role of a non-participant complete observer during classroom observations because I wanted to remain discreet with minimum interference. The video-recorded observations collected data that assisted me in addressing my three sub-research questions. Next, I discuss my process of conducting classroom observations.

3.3.6.1 Conducting classroom observations

To answer my three research questions stated in Section 3.0, I conducted classroom observations. In this study, I conducted three lesson observations with each of the four participant teachers while teaching the same class consisting of learners of mixed races and abilities. These classroom observations were video recorded because a video can capture time-scale events with detailed accounts of the environment and interaction (Beeli-Zimmermann et al., 2020). As a backup, these classroom observations were also audio recorded in case something went wrong with the main camera. In the lessons that I observed, I also used an observation tool to take field notes to augment the data captured by the video since the video may not capture every aspect of the complex classroom interactions. I did not observe three lessons out of twelve thus, I could not take field notes for these lessons because I was not able to visit the teachers (schools) because of COVID-19 restrictions. Hence, I had no option but to ask the teachers to record themselves while teaching genetics. The teachers did quite a good job as there was no problem. In this thesis, I provide links to the observation data in Appendix C. An example of a classroom observation transcript is shown in Appendix C1.

3.3.6.2 Mrs. Durand of School A

In her first lesson, Mrs. Durand intended to introduce the topic of *meiosis* though most of the time was spent on revision of the concept of mitosis. During the second lesson, Mrs. Durand introduced the concept of *genetics* using Gregor Mendel's work to the same learners. Lastly, Mrs. Durand was observed while focusing on *genetic crosses* though a large part of the lesson was spent on a recap of Mendel's work. Mrs. Durand's three lessons observed were conducted in a laboratory which consisted of a teacher's demonstration table and whiteboard in the front. The learners sat on stools facing the front behind fixed tables that accommodated three learners each.

3.3.6.3 Mr. Zindi of School A

In his first thirty-five-minute observed lesson, Mr. Zindi was teaching the concept of *meiosis,* though most of the lesson time was spent on the recap of key concepts and the concept of *mitosis* like in Mrs. Durand's first lesson observed. Mr. Zindi's second observed lesson was thirty-five minutes long where he introduced the topic of g*enetics* using Mendel's work to discuss key *genetics* terms. Mr. Zindi's last lesson observed was thirty-five minutes long where he was focusing on genetics crosses. His lessons were conducted in a laboratory that consisted of a teacher's demonstration table and whiteboard in the front of the classroom. The learners sat on stools in front of fixed tables which accommodated three learners each.

3.3.6.4 Mrs. Letsiba of School B

Mrs. Letsiba was first observed while engaged in a thirty-five-minute lesson where she was teaching abnormal meiosis though most of the time was spent on recapping regular meiosis. The second observed lesson was also thirty-five minutes long where Mrs. Letsiba introduced the topic of *genetics* using Mendel's work though a large part of the lesson was spent on recapping *DNA*: *The code for life*. *meiosis*, and *reproduction*. In the last lesson observed, which was also roughly thirty-five minutes long, Mrs. Letsiba did a recap on *monohybrid crosses*, *dihybrid crosses*, *blood groups*, and *paternity* and then focused on *mutations*, *sex-linked condition*s, *genetic crosses* involving *haemophili*a, and *pedigree diagrams*. Mrs. Letsiba's lessons were conducted in a traditional classroom that consisted of standard individual desks and chairs. The teachers's table was located at the back of the classroom and learners sat facing the chalkboard at the front.

3.3.6.5 Mr. Zulu of School C

Mr. Zulu's first observed lesson was thirty-five minutes long, in which he revisited the concept of *mitosis* while the second lesson observed, which was also thirty-five minutes, focused on *monohybrid crosses*. In his last lesson, which was seventy minutes long, Mr. Zulu focused on **dihybrid crosses** and *pedigree diagrams.* Two of Mr. Zulu's observed lessons were conducted in a laboratory consisting of a teachers' demonstration table and chalkboard in the front.

Learners sat on stools behind fixed tables facing the front. His last observed lesson was conducted in the school hall to allow for social distancing due to COVID-19 protocols.

3.3.7 Interviews

There are different forms of interviews, but for this discussion, I considered two types which are structured and semi-structured interviews. When bigger samples are studied, the structure and standardisation of closed questions become relevant resulting in structured interviews. While dealing with small samples which employ a combination of open and closed questions usually associated with follow-up questions (Yin, 2015) there are semi-structured interviews embedded in it (Flick, 2022). This study sought to obtain an in-depth understanding of the teachers' Discourse (use of science language in their classrooms) during the teaching of basic genetics to grade 12 learners. This endeavour involved studying a small sample of four participant teachers. Consequently, this study adopted semi-structured interviews for data collection. These semi-structured interviews were meant to augment the classroom observation data. To ensure, systematic data collection, I had a set of preconceived questions in the form of an interview schedule (Appendix B1). This interview schedule consisted of eleven main questions which were divided into four sections eliciting personal information, teacher's knowledge/awareness, teacher's strategies as well as context and other factors associated with language in use. During the interviews, these questions were supplemented with sub-questions to probe what was said in response to a question (Flick, 2022). An in-depth study would not be possible through the use of structured interviews using questionnaires for example. Adams (2015) argues that the reasonable maximum length of semi-structured interviews should be about one hour to minimize fatigue for both interviewer and interviewee. Hence, my interviews were scheduled between thirty to forty-five minutes and were audio-recorded. In this Thesis, samples of interview transcripts are provided in Appendix B, for example, Appendix B2.

3.3.7.1 Preparation for teacher interviews

After conducting the twelve classroom observations with the four participant teachers, I watched each teacher's three recordings and then compiled interview questions based on how the individual participant teachers the science language in their respective classrooms. This implied that the interview schedules for the four teachers were slightly different although some of the questions were the same.

3.3.7.2 Conducting interviews

After compiling interview questions for each participating teacher based on the language issues that arose from their lessons, I conducted the interviews at venues where participants were comfortable though two sessions were conducted online because of COVID-19 restrictions. These online interviews were recorded. Online interviews were advanced during lockdown and social distancing times where face-to-face interviews were not possible (Flick, 2021). Therefore, after the interview sessions, I thanked each of the participant teachers.

3.3.7.3 Exiting the research site

In this study, the data collection process involved observing the four participant teachers three times each while teaching the topic of *genetics* and conducting a follow-up interview session with each one of them. The interview sessions concluded my data collection process. Thus, after the interview sessions, I thanked each teacher for participating in my study and promised to make the findings of the study available to them. The way I conducted the classroom observations and interviews may have been influenced by my positionality. Therefore, I declared my positionality in terms of who I am and my beliefs about teaching life sciences in Chapter 1 Section 1.7. I did this because positionality might influence how the researcher approaches the research, and its results (Holmes, 2020).

3.4 Data analysis procedure adopted for this study

My analysis process started with the preparation of the data for transcription and entry into ATLAS.ti software by creating classroom observations and post-observation interview folders on my desktop. This was followed by the transfer of the data from the recording instruments to the respective folders. To address the issues of anonymity and confidentiality, I renamed the folders and the files with pseudonyms, so that there was no link between names or identities to the data (Flick, 2022). This was then followed by the actual transcription process. Transcription is the process of making a written, printed, or typed copy of words that have been spoken (McMullin, 2023). Transcription was conducted on the twelve classroom observation videos and four post-classroom observation audios. A detailed account of the transcription process is provided in Chapter 4 Section 4.4.1. Besides handling confidentiality, credibility issues were considered through member checking where the participants read and certified the transcripts as correct (Birt et al., 2016). During the transcription process, the observed lessons were divided meaningfully into episodes which were then used as the unit of analysis. In this study, I refer to the episode that qualified to be analysed as the ‘Discourse Episode’ which is the episode consisting of science talk. (See Chapter 4 Section 4.6.3 for more details and examples) In this study, for analysis, I amalgamated Lemke, Mortimer, and Scott’s frameworks. I merged the two because, like Mortimer and Scott (2003), I believe that communicative approaches are central to the teacher’s Discourse. I found Lemke’s Thematic analysis to lacking in this respect. Hence, I amalgamated Lemke’s Thematic Analysis and Mortimer and Scott’s Communicative Approaches, patterns of Discourse, and teacher interventions (teacher Discourse moves) to fill this void. To analyse the data, I coded the episodes consisting of science talks using ATLAS.ti software according to the coding scheme presented in Table 4.3. A detailed account of the analysis process is presented in Chapter 4.

3.5 Trustworthiness

Validity and reliability are key measures to keep in mind when conducting quantitative research while trustworthiness is of paramount importance to qualitative researchers (Creswell et al., 2016). As alluded to earlier, the researcher is considered the primary instrument for data collection and analysis in qualitative research (Merriam & Tisdell, 2015). It, therefore, follows that qualitative research cannot be purely objective because researchers are only human, whose perspectives, understandings, and biases can interfere with their work (Yin, 2015). The key to the trustworthiness of a qualitative study is transparency and this is achieved when the researcher spells out the systematic methods and techniques as well as the theoretical basis of his/her study (Adler, 2022). To ensure trustworthiness in my study, I tried to be transparent in terms of the methods, techniques, and theories underpinning my study and justified why these procedures were selected. For instance, in Appendices B, C, and D I provide a full set of data collected from all participant teachers which include classroom observation transcripts, post-classroom interview transcripts, and field notes. Particularly, I also provided an appropriate representation of the issue that was under investigation in my study (characterising the teachers’ Discourse during the teaching of basic genetics in South African classrooms). I tried to be transparent throughout the research process from my research design, preparation, data collection, and analysis to the presentation of findings.

Reflexivity is key when it comes to assessing the trustworthiness of qualitative research and it means that researchers need to reflect and share with readers how their social positions and those of participants may interfere with the researcher’s ability to maintain objectivity (Merriam & Tisdell, 2015). These effects have the potential to create bias and misunderstanding. Thus, in this chapter, I presented my epistemological orientations As well as my positionality.

3.5.1 Reliability/Credibility

On the one hand, reliability refers to the stability and consistency of the scores obtained from a specific instrument (Creswell et al., 2016). On the other hand, a credible study assures that the researcher has properly collected and interpreted the data so that the findings and conclusions accurately reflect and represent the world that was studied (Yin, 2015). Since my study adopted a qualitative case study approach, credibility was enhanced in various ways. Firstly, I adopted well-established research methods, research design a theoretical framework that fitted my topic and research question (Creswell et al., 2016). To be specific, my study was about teachers' Discourse, my research questions talked about Discourse while the overarching theory was Gee's theory of Discourse. Moreover, I video-recorded my classroom observations and audio-recorded the interview conversations.

Secondly, the relationships that I developed with my participants, my well-defined purposive sampling, and detailed data collection methods as well as the use of multiple data sources for triangulation enhanced credibility (Creswell et al., 2016). Thirdly, the frequent debriefing sessions that I had with my supervisors through meetings went a long way to ensure that credibility was maintained in my study. These debriefing meetings widened my views and assisted me in redefining the research questions until they addressed all cases within my data. In the same vein, the University of Witwatersrand School of Education conducted peer scrutiny sessions in the form of PowerPoint presentations during PhD research weekends which gave me opportunities to share my study and get constructive feedback. In addition, while enrolling as a PhD student, I presented my proposal and parts of my analysis sections in Research Schools and conferences organised by the Southern African Association of Research in Mathematics, Science and Technology Education (SAARMSTE) from 2019 to date. Furthermore, I also presented my findings at the European Science Education Research Association (ESERA) Conference in the year 2021. I received interesting feedback from my peers and academics. Moreover, the questions and ideas from peers and academics also assisted me to refine my methods, and research design and strengthen arguments.

Lastly, member checking (Merriam & Tisdell, 2015) where the participating teachers were allowed to read and correct the transcriptions enhanced the credibility of my study. Also, to ensure credibility the researcher audio recorded the classroom observations and interview conversations.

3.5.2 Transferability, Replicability and Reliability

Transferability is another concern in qualitative research which refers to the degree to which findings from one research study can be applied to other settings or groups of people (Anney, 2014). Creswell et al. (2016) state that in qualitative research transferability corresponds to the concept of generalisability in a quantitative research methodology. Unlike generalisability which advocates for general claims (Smith et al., 2017), transferability recommends that findings gained in a particular context can offer valuable lessons to other similar settings (Creswell et al., 2016). Transferability requires ensuring that the behaviours and observed events are typical or atypical of the lives of the participants, the need to provide complete details of the research design, context and participants under study (Creswell et al., 2016). To ensure transferability, in Chapter 2, I provided a detailed description of the context in which this study was conducted. Further, in the current chapter I have provided a detailed account of the participant teachers and my research design. This will allow the research readers to make their own decisions in terms of transferability.

Another concern of quality is replicability which speaks of whether the same results will be obtained on the same phenomenon if the study is repeated (Aguinis & Solarino, 2019). This endeavour is difficult when it comes to qualitative research because individuals are unique. This is more difficult in qualitative research because of the uniqueness of individuals. However, in qualitative research, the notion of ‘'reliability’ refers to the researcher's integrity in making sure that the data are recorded, analysed, and represented properly. In this study, I have showcased the analytical procedures (Chapter 4) that led to the findings reported. In other words, Chapter 4 which presents a broad overview of my data processing and analysis procedure enhances the ‘reliability’ of my study. Furthermore, to ensure ‘reliability’, after developing my coding scheme and using it on one of my participant’s classroom observation transcripts, I asked a colleague who was also a PhD student pursuing a similar study to code the same transcript. Details of this process are provided in Chapter 4. This practice is meant to ensure inter-coder reliability which is applied to measure the degree of agreement between coders when they apply codes to related data units in a transcript to validate coding. Next, I present a critical reflection of the research process.

3.6 Critical reflection of the research process

How the study progressed

Passing my Masters Degree with Distinction in 2017 motivated me to register for PhD studies with Wits University the same year. This study started on a very sad note in the sense that when I was about to submit my proposal for examination the supervisor with whom I was initially registered left the university in 2018. I was then assigned to new supervisors who found my original work lacking in terms of theoretical framing. Owing to this, I had to reconceptualise my study and ended up focusing on teacher's Discourse which marked the beginning of my new PhD journey. I must say that the change from my old supervisor to my current supervisors was a blessing in disguise. Though the departure of my first supervisor delayed my process by one year, the reconceptualization process that I went through resulted in my study becoming better and having a clearer focus. So, I ended up focusing on the teachers' use of language in their contexts which Gee (2017) refers to as Discourse with an upper case 'D' instead of just focusing on the teachers' use of science technical terms. Working with my new supervisors was a blessing in the sense that they had a lot of interest in academia to which they quickly introduced me. They encouraged me to become affiliated to research associations such as SAARMSTE and ESERA from which I have learned a lot throughout my academic journey. After attending my first SAARMSTE Research School in 2019, I submitted my proposal for examination and got my candidature and ethics clearance the same year. I then started collecting data in February 2020. Data analysis started the same year (2020) as I was collecting data and ended at the beginning of year (2024).

Obstacles to the research

Carrying out research in classroom environments is notoriously difficult, as any attempt to acquire empirical data tends to interfere with the teaching and learning experience (Hatch, 2023). To minimise this, in the classrooms where I personally recorded the videos, I stationed myself at the back of the classrooms where the learners and teachers alike could not see me easily. My strategy was to acquire observation and interview data to determine the teachers' Discourse during their teaching of basic genetics. Similar methods have been used successfully in many studies of the interactions in classrooms (Axelsson & Jakobson, 2020; Lin & Lo, 2017) though it was uncertain to what extent the data collection process altered the teaching and learning experience. The major obstacle that I encountered during data collection was the onset of the COVID-19 pandemic which ushered us into lockdown. This meant that l could not continue with the data collection process since schools were no longer allowing visitors onto their properties. To counter this problem, I had to ask the teachers to video record themselves while they taught genetics. This is where I saw the importance of sound researcher and participant relationship (Anderson & Henry, 2020). My problem was not yet resolved because I could not access the video recordings due to lockdown restrictions. I could not visit the teachers to fetch the videos neither could they send me the videos via WhatsApp or email because they were large files. Therefore, I had to wait for the lockdown restrictions to be slightly eased for me to get the video files from the teachers. The good relationships that I had established with the participants made it easy for me to conduct online interviews with two of the teachers who offered to use their own data/Wi-Fi during the interview sessions.

The other obstacle was that the analysis process was painstakingly slow, undertaken by me as the only researcher, on a part-time basis. This has contributed to a major limitation of the study. The long time lapse between data collection process (2020-2023) and final writing up of the research in this thesis, though two conference proceedings articles based on the data were published in the interim. In many areas of research this would render the findings obsolete as conditions and contexts change rapidly. However, as has been indicated in Chapter 1, generally there have not been noticeable improvements in learners' achievement in life science (see Table 1.1 Chapter 1); and the education challenges in Gauteng (Johannesburg) remain fundamental and relatively stable if not worse because of COVID 19.

The other challenge that I faced was how to deal with the feedback from my supervisors which I sometimes found to be harsh. While they were guiding and critiquing my work as my supervisors, after every feedback session I would go back and reflect on the feedback and work on it. Eventually, I got used to the feedback and considered it to be part of my academic growth process. Below is an example of feedback that was in response to the first draft of my Chapter 5 (first findings chapter):

Dear Shungu,

I have skimmed your 90 page chapter, and I must say, the 90 pages were already a red flag, and I need to say up front, that this is not what is expected when you provide analysis. I am starting to think that you do not have a clear idea of what you are expected to do in the chapters. The answer is that you are required to produce salient analysis that will enable you to answer your research questions at the end in terms of your theory and using your *method of analysis. What you have at the moment is repetition of data under different headings and it is not taking your work forward. One immediate guideline I can give you is that if your chapter goes over 35 pages, you are not on the right track. One thing that helped me enormously when I was writing up my PhD was to have another thesis to guide me. What I have done is to write to ... who once told me she examined a brilliant thesis on Language in science education and ask for the name of the candidate. She replied to me, and I have downloaded the thesis. It is attached to this email I was going to try and send you my thesis as part of it was about analysis of teaching, but it is from 1988, before the days of PDF. However, I have also attached an article I wrote from the observations – I thought that may help as well. I suggest you have a look at what I have sent you , and by the time we meet next time, you can just send an outline of the chapter and we can discuss it.*

…………..

When I was reading the feedback above for the first time, I was overwhelmed and felt like I was not capable of completing this Degree Program hence, wanted to quit. However, when I read it for the second time, I realised that there was an action plan which then motivated me to move on.

Successes

My affiliation with academic research associations such as SAARMSTE, ESERA as well as the Wits PhD community (Research weekends) accelerated the submission of my research proposal for examination. My supervisors funded me so that I could attend the SAARMSTE Research School for the first time in 2019. In the same year, I obtained candidature for my PhD studies. Since then, my supervisors have been affording me opportunities to attend the SAARMSTE Research School and Conferences. These activities have contributed a lot towards my growth during my academic journey. In addition, these research schools and conferences have helped in terms of networking, such that I never felt lonely during the COVID-19 era. Though the whole world was under lockdown, I still had an opportunity to network virtually (at SAARMSTE Research School) with colleagues and academics from all over the world in (2020-2022) through Zoom. Of all the research schools I have attended, the one I attended in 2023 was a game changer in the sense that I got assistance in terms of mapping the teachers' Discourse from my data which was the highlight of my study. My affiliation with SAARMSTE has been great in the sense that it has allowed me to publish two papers (current work and Masters' work) in SAARMSTE peer-reviewed conference books of proceedings. Furthermore, my affiliation with ESERA has also contributed towards my academic growth and allowed me to publish a paper from my current work in ESERA's conference book. Eventually, I came up with a new model which I refer to as the Discourse Teaching Strategy Model which constitutes the new knowledge developed from my study. This model will be presented in Chapter 7, and will be simplified, and analysed in Chapter 8. In the next section, I present a summary of this chapter.

3.7 Chapter Summary

This chapter dealt with the research design and methodology of the study. The sampling, data collection as well as the analysis methods were discussed. The rationale for choosing all these methods was provided. Further, issues of trustworthiness, credibility, transferability, replicability, and reliability as well as ethical considerations have been discussed. In the next chapter, I present a broad overview of my data processing and analysis procedures.

CHAPTER 4: BROAD OVERVIEW OF DATA PROCESSING AND ANALYSIS PROCEDURES

4.0 Introduction

This chapter presents a broad overview of this study's data processing and analysis procedures. In particular, it discusses the details of the sources of data used in this study, preparation of data for transcription, and preparation of data for entry into ATLAS.ti software and the analysis process. In this chapter, issues of credibility trustworthiness and ethics are duly considered.

4.2 Sources of data

4.2.1 Lesson Observations

Video-based classroom research has been advocated in classroom research because of its ability to capture time-scale events such as classroom lessons with detailed accounts of the environment and interaction (Beeli-Zimmermann et al., 2020). Nonetheless, the video is not able to fully capture every aspect of complex environments such as classroom lesson interaction. Hence, there is a need for a researcher to employ other sources of data to augment the data captured by the videos, such as the classroom lesson observations used in this study. Other sources of data (post-lesson observation interviews and field notes) were used for data triangulation purposes and to augment classroom lesson observation data. This helped me to access teachers' rationale for taking certain actions during the observed lessons. Moreover, the interviews provided more information for answering sub-research questions and enhanced the trustworthiness of my analysis as the various data collection methods complemented each other. This is supported by Nowell et al. (2017) who maintain that looking at a situation using a combination of different ways enhances trustworthiness.

The sources of data for this study are the four participating teachers' (Mrs. Durand, Mrs. Letsiba, Mr. Zindi and Mr. Zulu) observation video recordings and one observation audio recording as well as post-lesson observation interview recordings. Three videos which were recorded at different stages of their teaching of the topic 'genetics and inheritance' were analysed. The lessons ranged between thirty minutes and two hours. The first set of data was drawn from videos that were recorded when the participant teachers were teaching the general topic 'meiosis' and are referred to as Dataset 1 (consisting of Lesson Observation 1 for the four participant teachers) in this study. The second set of data was recorded when the participant teachers were introducing the general topic 'genetics and inheritance', these are referred to as Dataset 2 (consisting of Lesson Observation 2 for the four participant teachers) in this study. The last set of data referred to as Dataset 3 (consisting of Lesson Observation 3 for the four participant teachers) was recorded when the participant teachers were teaching the general topic 'Mendelian genetics'. Therefore, this study had twelve video recordings for all the participating teachers and one audio for Mr. Zulu which was recorded as a back-up. Thus, a total of 454.22 minutes of corpus of classroom lesson observation video-data collected from the four participant teachers' classrooms produced a total of 746 pages with 12-font size and 1.5-line spaced narrative data text (refer to Appendix C2 for a sample). This included technical transcript additions such as indicators of pauses, intonations, other audible non-verbal phenomena, and pictures that were screenshots from the videos (these will be discussed in detail later in section 4.4). The video data are housed in my laptop which is password protected as well as on a memory stick and external backup hard drive which are kept in a locked cabinet and on my Microsoft OneDrive account and Google Drive. The data corpus analysed in this study is presented in Table 4.1 below.

Table 4. 1: Data Corpus analysed in this study

Dataset	**Participant Teacher**	**Scheduled lesson or interview time/mins**	**Data format**	**Length/mins**
1 (Lesson Observation 1)	Mrs. Durand	45	Video	30.00
	Mrs. Letsiba	40	Video	30.00
	Mr. Zindi	45	Video	35.00
	Mr. Zulu	35	Video	25.00
2 (Lesson Observation 2)	Mrs. Durand	120	Video	40.24
	Mrs. Letsiba	40	Video	35.00
	Mr. Zindi	120	Video	48.00
	Mr. Zulu	40	Video	41.08
			Audio	
3 (Lesson Observation 3)	Mrs. Durand	120	Video	34.42
	Mrs. Letsiba	60	Video	36.06
	Mr. Zindi	120	Video	50.00
	Mr. Zulu	120	Video	48.31
4	Mrs. Durand	30	Audio	36.06

Dataset	Participant Teacher	Scheduled lesson or interview time/mins	Data format	Length/mins
(Interviews)	Mrs. Letsiba	30	Audio	60.00
	Mr. Zindi	30	Audio	49.12
	Mr. Zulu	30	Audio	51.11
NB: The audio was included in Mr Zulu's lesson observation 2 because the captured video was incomplete due to a technical problem encountered during the recording				

The data corpus above shows that some lessons that were scheduled for 120 minutes (double lessons) ended up being half (single lessons) of the allocated time because the teachers preferred to be observed during single lessons. However, it was a different case with Mr. Zulu's first observed lesson which only lasted for twenty-five minutes instead of thirty-five minutes. The ten minutes were lost during changeover time because his learners took too long to come to the laboratory from the previous lesson. It is most likely that these learners lost valuable teaching time in this lesson. It was however, not the general trend for Mr. Zulu's lessons since the learners were punctual for the other two observed lessons.

4.2.2 Post-classroom Observation Interviews

The other sources of data were the post-lesson observation interview audio recordings that were recorded once after each teacher's three lessons observations were concluded. These post-observation interviews were conducted to gather data about the four participant teachers' background information, perspectives, views, and experiences of teaching the topic 'genetics' to grade 12 learners. In other words, the interviews allowed the participant teachers to share stories about their practices. Furthermore, these follow-up interviews with each participant teacher were conducted to obtain clarity on Discourse-related issues arising from the lesson observations.

4.2.3 Field Notes

During each lesson observation, indexed field notes capturing the topic of discussion, setting and environment, number of learners, names of actively participating learners, objects, technologies, and external texts brought by teachers and learners to augment the lesson were recorded. Recorded indexed field notes for each lesson observation were transcribed from rough to typed form on the same day they were taken. An example of rough field notes taken during Mr Zulu's Lesson Observation 2 is shown in Figure 4.1.

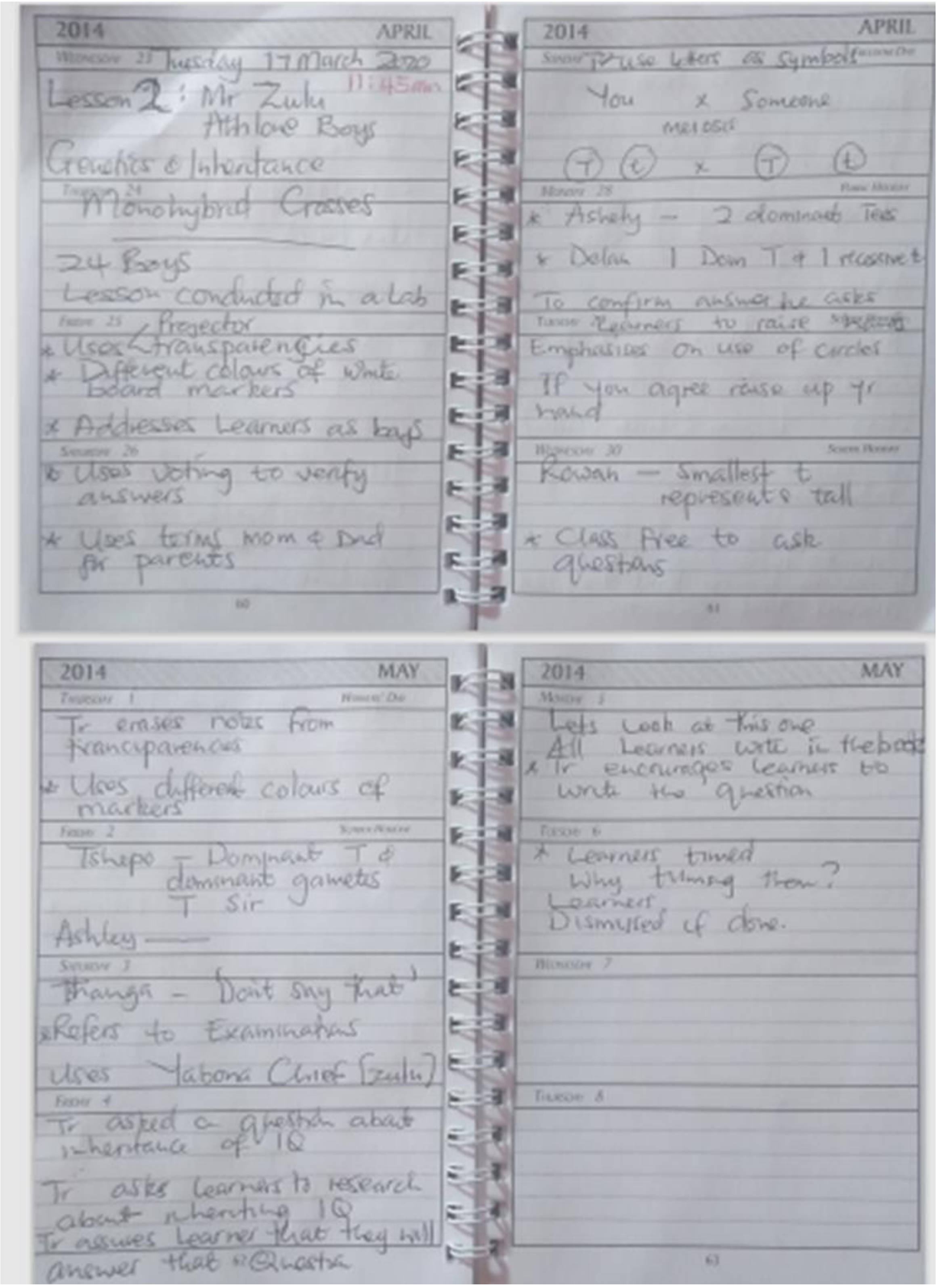


Figure 4. 1: An example of field notes

The indexed field notes were useful during the process of transcribing the lesson observations especially when some parts of the videos were inaudible. Also, they helped me to attach names to voices where the videos were not clearly audible. Overall, they assisted in synchronizing multiple data sources to produce an accurate representation of teachers' Discourse.

4.3 Preparation of data for transcription

4.3.1 Classroom lesson Observation video recordings

Preparation of data for transcription started with the creation of a three-lesson observations folder for each participant teacher on my desktop. Thus, each participant teacher had three folders for the lesson observations. This was done to make sure that each teacher's data was captured on the desktop of my computer. This was followed by the transfer of lesson observation videos from the recording devices (camera, two smartphones, and tablet) to the appropriate folders on my desktop. This transfer was accompanied by the process of renaming the videos, making sure that the lengths and sizes of the videos were maintained. These were renamed with the participant teachers' pseudonyms, for instance, Mr. Zindi L3_Part 2_12.48 min. The pseudonyms used for the participant teachers have a first letter that is the same as the participant's real name to assist in retaining contextual and referential information. 'L3' on the pseudonym shows us that it represents Lesson Observation 3. Each lesson could have two or more parts because the camera would split the lesson into two or more videos. The process discussed above was done on the day the lesson observation was conducted. After renaming, the videos for the same lesson were then transferred into the appropriate folder according to the participant teachers. After conducting all lesson observations, a catalogue of the observation videos was then made, where all observation videos were classified as Datasets based on whether they represented the first, second, or third lesson observation. That is, grouping all videos from Lesson Observation 1 together in one folder and named Dataset 1 while all videos from Lesson Observation 2 in the same folder are named Dataset 2. Lastly, all videos from lesson observation 3 for all four participant teachers were filed in one folder which was named Dataset 3. The three datasets were then transferred into a big folder labelled PhD Data. The videos were watched three times each and then the interview schedules for four teachers were modified according to what would have transpired during each participant teacher's three observed lessons. Each participant teacher was given copies of his/her classroom lesson observation videos for them to watch ahead of the interviews.

4.3.2 Post-lesson observation interview audio recordings

Preparation of interview audio recordings like observation interviews started with the creation of an interview audio recording folder for each participant teacher on my desktop. This was followed by a transfer of the interview audio recordings from the recording devices (two smartphones and a tablet) to my desktop. As discussed above in Section 4.3.1, the audio recording renaming process would follow with a different naming format since these are now interviews, for example, Mrs. Letsiba_In_60 min where 'Mrs. Letsiba is a pseudonym starting with the first letter of the participant teacher's real name as alluded to earlier, 'In' shows that it is an interview, and 60 min shows the length of the interview audio recording. The process discussed above was conducted on the day of the interview. When all four interviews were conducted with the four participants, a folder for the interview audios was created and then transferred to the catalogue discussed under preparation classroom observation videos above. To get acquainted with the interview audio, I listened to the audio recordings three times as done with the classroom lesson observation video recordings.

4.4 Transcription

Transcription is the process of making a written, printed, or typed copy of words that have been spoken (McMullin, 2023). In this study, the process of transcription was conducted on videos and audio. Outlined next is the transcription process that was followed in this study.

4.4.1 The Transcription Process

Step 1: Deciding on who does transcription

In this study, I decided to transcribe the audio and video tapes on my own. This decision was motivated by Savin-Baden and Major (2023) who argue that when researchers hand over the audio or video tapes as a "chore" to be done by other people, they "miss out on the kinds of understandings that develop as tapes are transcribed as well as lose control over some of the transcription decisions made". This is supported by Point and Baruch (2023) who emphasised that transcription is not just about the transcription product but the verbatim words that are written down are important. They further argue that analysis begins with transcription, as understandings are derived from the construction of a transcript through listening and re-listening, viewing, and re-viewing the audio or video recordings. Though it is time-consuming, I decided to do my own transcription because I wanted to be close to my data (Clark et al., 2017) and get an opportunity to conduct the initial analysis of the data on my own.

Step 2: Familiarisation through video and audio playback

The first step in transcription is the process of familiarization that involves close observation of data through repeated careful listening and/or watching (Kowal & O'Connell, 2014). They further argue that this stage involves immersing oneself in the data much more deeply accompanied by jotting notes about what the researcher sees, and thinks is going on in the data.

Hence, this familiarization time helps the researcher to get a general sense of the information and reflect on its overall meaning. Owing to this, I watched and listened to the video and audio recordings three times each to familiarize myself with the data which was accompanied by jotting down notes about each teacher's actions during the lesson observations. The notes made as I listened to the videos also assisted me in redesigning the interview schedules for each participant teacher. The use of videos and audio to record classroom lesson observations and interviews assisted me in ensuring credibility since they captured true pictures of the lessons and interview sessions. More so, the video and audio recordings were played three times to obtain a true record of the lessons and interviews thus ensuring credibility.

Step 3: Choosing the preferred transcription method

According to McMullin (2023), transcription can assume different forms such as verbatim transcription, intelligent verbatim transcription, and edited transcription. He further asserts that firstly, verbatim transcription entails writing down every single word as well as pauses, and expression of emotions such as laughter and hesitations. This type of transcription is engaged in research where the researcher is not only interested in what is said but also how it is said. Secondly, intelligent verbatim transcription is a process where certain elements of speech are omitted if they add no meaning to the transcript which are mainly, repetitions and false starts This is used in scenarios where the meanings of what was said are more important than the exact wording that was used. Lastly, in edited transcription, a full and accurate script is formalised and edited so that it is readable and clear. This type is usually used by lecturers or conference organisers who need the content written in a formal way. This study sought to characterize the teachers' classroom Discourse when teaching basic genetics in South African classrooms. This was done by focusing on how teachers used language in their contexts. This meant that I was interested in what was said as well as how it was said. Owing to this, the study adopted the verbatim transcription method for transcribing the data. To add to that, the verbatim transcription method was chosen for this study because a combination of verbatim transcription and researcher notation of non-verbal behaviour is considered to be central to the reliability, validity as well as veracity of qualitative data collection (McMullin, 2023).

Step 4: Deciding on what to transcribe and the level of detail

What to include during transcription should be driven by the sub-research questions that the study attempts to answer. This study was guided by the following sub-research questions:

1. *How do teachers develop genetics concepts during the teaching of basic genetics to grade 12 learners?*
2. *What forms of interaction patterns and teacher Discourse moves are evident during the teaching of basic genetics to grade 12 learners?*
3. *What kinds of emergent teacher Discourse strategies can be extracted from teaching basic genetics to grade 12 learners?*

A look at the sub-research questions shows that the first and third sub-research questions may not be fully answered without considering the context. On the one hand, the development of genetics concepts cannot be achieved in isolation from the context in which it is being done. On the other hand, the emergent teacher and student strategies used during the teaching of genetics can be considered as context. Thus, the two sub-research questions discussed above established the rationale for including non-linguistic observations such as facial expressions, body language, and setting descriptions during verbatim transcription.

Clark et al. (2017) argue that the level of transcription needs to match the level of analysis to be performed. This study sought to obtain detailed accounts of how life sciences teachers use language in their contexts when teaching basic genetics to grade 12 learners. Detailed accounts imply that analysis in this study sought to provide an in-depth description of the knowledge, attitudes, values, beliefs, or experiences of individuals. Hence, the text included in the transcripts needed to be long. I was not interested in identifying patterns and salient themes only but intended to demonstrate variations on how Discourse as a phenomenon is framed, articulated, and experienced by the participants. Thus, the transcription level chosen for this study is full transcription where all video recordings for lesson observations and audio recordings for interviews were transcribed fully rather than partially or providing summary transcriptions.

Step 5*:* Deciding on what to do with the content

The focus of this study was spoken discourse, which is accompanied by features that play an important role in conveying the meanings of words. Gestures, body movements, pauses, changes in gaze direction and facial expression, and changes in voice tone and pitch are all examples of such features that accompany spoken discourse (Gee, 2017). Thus, in this study, all video recordings and audio recordings were transcribed verbatim (recorded word for word, exactly as said), including any non-verbal or background sounds such as laughter, sighs, coughs etcetera (Lim, 2019).

In this study, non-verbal sounds were typed in brackets on the transcripts for instance, [laughter] or [noise in the corridors]. Audible speech is presented in different forms that are different from the written language which is standardised in particular ways (Clark et al., 2017). In this study, such speech was standardised using grammar and spelling conventions of standard British English to aid readability. In addition, filler words such as 'ahh', 'ehh', 'ehm', and word or phrase repetitions were all transcribed. The transcription conventions selected for use in this study are presented below in Table 4.2.

Table 4. 2: Transcription conventions used for transcription

Symbol	Signification
T:	A verbal contribution belonging the teacher
L:	A verbal contribution belonging to any individual learner
Ls:	A verbal contribution belonging to two or more learners
…	Noticeable pause of less than 1 second in a turn, which could be due to reformulation or hesitation
—	Sound abruptly cut off e.g false start Truncated word Formal made shorter e.g S-
/ /	Words between slashes show uncertain transcription (not clearly known or understood.
/ ? /	Inaudible utterances
[ ]	Words in brackets indicate non-linguistic information eg [pause for 1 second] Laughter, throat clearing, smile, applause, sigh happily/ werily/deeply, contently, swallowing, nodding, shaking head dance or movement towards/away
( )	Parenthesis around tone units indicate words spoken in a sotto voice under one's breath (in a very quiet voice)
,	Slight pause
?	High rising intonation
.	Falling intonation at the end of tone unit
:	Colon following a vowel, indicates elongated vowel sound or extending length of sound e.g Die:d
::	Extra colon indicates longer elongation
↑	A step up in pitch/ high pitch (high quality sound)
↓	A shift down in pitch (low quality sound)
^	A caret indicating high pitch level e.g ^weird
-	Low pitch level
— —	Self-interruption or repair
abc	Best guess transcription
ALL CAPS	Utterance is louder/said with extra stress/emphasised compared with surrounding words
/	Rise tone e.g …saying something, /
\	Fall tone
V	Fall-rise-tone
Λ	Rise-fall-tone

Adopted from Gee (2010)

Step 6*:* The actual transcription process

Once my data corpus was organised and I had familiarised myself with it, the next step was to transcribe all the data (video and audio recordings) to analyse it in depth and share it with others in a written research report and publication. As a positivist, I ensured that my transcripts (video and audio) were reliable and valid because the recorded videos and audio corresponded with the original conversational events (observations and interviews). According to (Moore de Luca & Llompart Esbert, 2017) the process of transcription is usually done in two phases: firstly, researchers conduct a rough transcription process where details (gestures, pauses, or prosody) are omitted. Once the initial stage has been completed, the researcher then proceeds to include details of gestures, pauses prosody to produce finer transcriptions. Likewise, in this study, I conducted the process of transcription in two phases viz., rough, and fine transcription. Since the data corpus was already loaded on my computer, during transcription I watched, listened (using earphones), and typed the verbal interactions using the same computer.

Phase 1: Rough transcription

Rough transcription was done by watching and/or listening to the video or audio recordings and writing out the verbal content of interactions, without any specific symbols. This process involved pausing replaying and listening/watching carefully to get a clear understanding of what was taking place during the interactions. This phase constituted my initial analysis process because it assisted me in making decisions about what was going on during the interactions. Such decisions assisted me in redesigning the interview questions for each participant teacher. As I was working through the content of the interaction, I assigned certain utterances and actions to certain participants, for whom pseudonyms were used. During this phase, I had to decide what pseudonyms to use for each participant and kept a record because I was dealing with a large number of co-participants (especially Learners). I transcribed the data according to the datasets: firstly, Dataset 1 (Lesson Observation 1) followed by Dataset 2 (Lesson Observation 2) as well as Dataset 3 (Lesson Observation 3) and concluded with Dataset 4 (interviews).

Phase 2: Fine transcription

Once rough transcription was finished on all video and audio recordings, I went back to the rough transcriptions and added conventions (discussed in step 5) to best represent the multimodal features of the data that I intended to analyse in depth such as stress, gestures, and gaze in text form. Such a transcription (including embodied actions and references to the material and spatial environment) is referred to as a multimodal transcription (Moore de Luca

& Llompart Esbert, 2017). Fine transcription was then conducted according to datasets as discussed in phase 1 of transcription.

Step 7: Gathering evidence of social exchanges

In this study, evidence of social exchanges for lesson observations was gathered by pausing the video recordings and taking screenshots. These screenshots were then pasted on appropriate sections of the transcripts. These constituted evidence for non-verbal instances (images, pictures, gestures) and were used as pictures and artifacts from the lessons.

Step 8: Cleaning transcripts

The transcription process was followed by data cleaning since Rana et al. (2016) argue that all data sources potentially have anomalies which include errors and missing values. These anomalies can lead to problems such as linking errors or incorrect analysis leading users to draw false conclusions. Therefore, in this study, the data-cleaning process was performed through editing, validation, and imputation. During this process, I identified errors, in terms of grammar, punctuation, misspelt words and repeated words during the typing process (not repeated in the speech) and corrected them to enhance readability as well as understanding.

Step 9: Deciding on data management

The process of handling thousands of pages generated from transcripts is not an easy task (McMullin, 2023). Thus, the first step in making the task easy was to establish a format template so that each transcript had an identical structure and appearance.

Observation transcripts

I decided that each lesson observation transcript should have a transcription header which indicated the level of detail of the transcript, the name (pseudonym) of the participant teacher, the participant teacher's school (pseudonym), the lesson number, the topic as well as the date of observation as shown below.

"Full lesson observation transcript for Mrs. Durand of School A

Lesson 1: Meiosis on 11 February 2020"

Following the transcription header, were the lesson details in terms of teaching time, teacher's details (gender and nationality) as well as the class demographics. Next were details of the context in terms of the type of school and where situated. A note to the reader about the use of pseudonyms to maintain anonymity in the transcript then followed. This section of the transcript was concluded with details of the objects and technologies used by the teacher and learners during the observed lesson for instance textbooks or chalkboard and chalk. This section of the transcript was then followed by the conventions that were used during transcription some of which are presented in Table 4.2 in Step 5 above. The last section of the observation transcript represented the speech that occurred during the lesson.

Interview transcripts

Interview transcripts, like observation transcripts, had a template (Clark et al., 2017) which was used for all four participant teachers. The template had a transcription header for the interview specifying the level of detail of the transcript, name (pseudonym) of the participant teacher, Participant teacher's school (pseudonym), length of video, date of interview, place and/or form of interview. The transcription header was followed by the conventions used during transcription as alluded to earlier in the observation section above. Like the observation transcript, the last section of the transcript represented the speech that took place during the interview session.

Step 10: Handling confidentiality

Usually, during observations or interviews, participants or interviewees mention the names of others or provide detailed information about their own lives and others. In such cases, I had to determine if the inclusion of such information could result in personal or social harm, compromise the identity of my participants or interviewees, or otherwise breach confidentiality as suggested by (McMullin, 2023). Therefore, personally identifying information (names of participants, name of school and participants' faces) was removed from the transcripts. Participant teachers', participant learners' and other people's names mentioned in this study have been changed to pseudonyms to protect their anonymity. In terms of faces, I had to come up with a way of making the participants' faces blurry on the transcripts.

Step 11: Labelling, cataloging and member checking

Like the video and audio recordings discussed earlier, I had to determine a system for labelling and cataloguing the observation and interview transcripts. On the one hand, all the observation transcripts were labelled according to the participant teacher's pseudonym, lesson observed number, and the level of detail of transcription, for instance, Mrs. Letsiba's Lesson 1 Full Transcript. On the other hand, all interview transcripts were labelled according to the participant teacher's name (pseudonym) and the level of transcription (e.g., Mr. Zulu Full

Interview Transcript). All transcripts for lesson observation 1 for the four participant teachers were saved as Word documents and classified into one file which was labelled Dataset 1 Transcripts. The same was done for lesson observations 2 and 3 which were labelled Dataset 2 Transcripts and Dataset 3 Transcripts respectively. All four interview transcripts were also classified into one file and labelled Dataset 4 Transcripts. These transcripts were printed and stored in a locked cabinet and the soft copies were kept in my password-secured desktop computer. This information was also backed up in my password-secured laptop and external hard drive which is stored in a locked cabinet.

To ensure credibility, member checking (Birt et al., 2016) was conducted where another set of transcripts (Datasets 1-4) was printed, and each participant teacher was given his/her set of transcripts (lesson observations 1-3 and interview) for checking. This process allowed the participant teachers to read and correct or certify the transcripts as correct.

4.4.2 Challenges encountered during transcription

The process of converting speech into text is not without challenges. Verbal and non-verbal interaction together shape communicative meaning yet are hard to represent in a written transcript (Himmelmann, 2018). In this study, I encountered difficulties with transcribing speech that was accompanied by background noises from the corridor or intercom announcements. In such instances, I had to pause, replay, and listen several times until I thought I got the correct speech. In some cases, I experienced incomplete sentences or omissions of sounds between two words normally a vowel at the end of one word. This also meant that more time was spent on pausing, replaying, and listening to get the correct speech, meaning that more time would be spent at that particular point. The fact that I could pause, playback, listen and watch again ensured trustworthiness (Adler, 2022) as I strived to get the correct speech from the interactions. The lack of clear-cut endings in speech was another challenge experienced in this study during transcription. This also meant pausing, replaying, and watching/listening again as alluded to earlier. This was overcome by paying particular attention to how the participant teacher generally spoke and use that to determine the end or beginning of the speech.

During transcription visual data was more difficult to capture since they take more time to transcribe than speech. In addition, there are few conventions for representing these elements on a written transcript. This is supported by Himmelmann (2018) who maintains that any non-verbal or background sounds: laughter, sighs or coughs are difficult to capture in a written transcript.

4.5 Preparing data for further entry into ATLAS.ti software

This data was further prepared for entry into ATLAS.ti software which is a version of the new options in Computer Assisted Qualitative Data Analysis Software (CAQDAS) (McMullin, 2023). This process was initiated by creating an Easy Transfer or Suitcase folder on my desktop which was named '*An analysis of teachers' Discourse when teaching basic genetics concepts in South African classrooms'* (my research title). This folder was meant to store (for saving) all ATLAS.ti work from my documents including final outputs from my analysis. This was followed by preparing my documents (observation video transcripts) for ATLAS.ti. I created my own naming convention (my standard way of naming documents/files). These file names included signifiers such as demographics like gender, mode of data collection, observation and organisation like in school A. In ATLAS.ti documents can be saved as Word-processed files or pdf files. With Word-processed files, one can make changes in ATLAS.ti whilst no changes can be made on pdf files once they have been imported into ATLAS.ti software. Despite this, I decided to save my documents as pdf files since I wanted to maintain the originality of my transcripts (refer to **Appendix C2)** which had pictures (obtained from screenshots of non-verbal instances of pictures and lesson artefacts) that I intended to code, which was not possible with word processed files.

4.6 Data Analysis

The main objective of this study was to explore the teachers' Discourse by focusing on their use of language in their contexts. This study was mainly influenced by Gee's Theory of Discourse/discourse. Gee (2011) argues that there are numerous ways of conducting Discourse Analysis however, the manner in which it is done depends on what the researcher needs to do with the linguistic data available. This study focused on how teachers develop genetics concepts, the forms of interaction patterns, the types of teacher-student strategies and specific teacher moves extracted from the Discourse during the teaching of basic genetics. Consequently, a specific Discourse Analysis technique developed by Lemke (1990) called Thematic Analysis was adopted in this study as a lens for exploring and understanding the teachers' Discourse during the teaching of basic genetics. Definitions of the terms used for analysis in this study are listed in Table 2.2 of Chapter 2. Though some of the definitions were drawn from literature, the Figure shows how they are defined with reference to this study.

4.6.1 Thematic Analysis as a Framework and Method

In terms of the application of systemic functional linguistics in science education and research, Lemke's work of 1990 is notable. The central tenet of Lemke's work on the linguistic basis of learning science is his account of spoken language as "the medium in which we understand and comprehend" science (Lemke, 1989, p. 136). Learning science is doing science and doing science is "always guided and informed by talking science" Lemke (1990, p. xi), and hence "learning science means learning to talk science" (Lemke, 1990, p. 1). Doing and talking science work in tandem, neither precedes the other. Thus, he claims, that teaching science is teaching how to do science, which by implication means guiding students how to talk science. Talking science entails the following: "observing, describing, comparing, classifying, analysing, discussing, hypothesizing, theorizing, questioning, challenging, arguing, designing experiments, following procedures, judging, evaluating, deciding, concluding, generalizing, reporting, writing, lecturing, and teaching in and through the language of science" (Lemke, 1990, p. ix).

According to Lemke (1990), in science classroom Discourse there are two major activities performed. The first one is 'activity structure' which produces the 'organisational pattern' of the Discourse. Therefore, we construct 'organisational patterns' of classroom dialogue from 'activity structures' of Discourse. The organisational pattern of a classroom dialogue is defined as "the structure within which teachers and students talk science in the classroom" (Lemke, 1990, p. 11). Lemke asserts that a classroom lesson is a social activity which has a pattern of organisation (activity structure). Through the analysis of classroom episodes of various science lessons, Lemke identified different forms of activity structure of the classroom activities: "what is happening, what the options are for what comes next, and who is supposed to do what" (Lemke, 1990, p. 4) in a reasonably identifiable way. Through such analyses of various episodes of different classroom science lessons, Lemke found various patterns of organisation such as Triadic Dialogue, Teacher-Student Debate or Teacher-Student Duolog, Teacher Monologue, External Text Dialogue, True Dialogue and Cross-discussion. According to Lemke (1990), the most common and dominant pattern of organisation of classroom Discourse is Triadic Dialogue, which is a three-part question-answer-evaluation pattern. This concurs with what (Mehan, 1979) refers to as a triadic 'I-R-E' interaction. This type of interaction consists of three components, where 'I' stands for initiation which is usually through a question from the teacher 'R' stands for the response which is normally from the learner. Lastly, 'E' stands for evaluation by the teacher. This pattern of interaction was extended by Mortimer and Scott (2003) who identified an alternative form of triadic Discourse which they referred to as I-R-F (where F represents feedback). This occurs when the teacher gives the learner feedback instead of evaluating the learner's response. In some cases, the teacher elaborates on the learner's response to provide support for the development of his/her ideas. They further noted that this pattern of Discourse can occur in a chain of interactions as follows, I-R-F-R-F where the elaborative feedback (F) from the teacher is followed by a further response from the learner (R). Since (Lemke, 1990) only focused on Discourse patterns in terms of Question-Answer-Evaluation, this study adopted and integrated the patterns of Discourse as proposed by Mortimer and Scott (2003). This means that besides looking at Discourse patterns in terms of Question-Answer-Evaluation or I-R-E, I will also consider Discourse patterns in terms of I-R-F, and I-R-F-R-F interactions. The forms of patterns of Discourse discussed above do not occur in a vacuum but take place within specific communicative approaches. This has been found to be true by Mortimer and Scott (2003) who argue that the communicative approach is central to classroom interactions as shown in their analytical framework presented in Figure 2.1 in Chapter 2.

Though Lemke (1990) did not consider the centrality of the communicative approach aspect in classroom interactions, I recognise its importance since it characterises how teachers and learners interact as they work through scientific ideas and understanding. Therefore, this study adopted the communicative approach aspect as used by Scott and Ametller (2007), and integrated it into Lemke's Thematic Analysis approach as a sub-category of the interaction patterns shown in Table 4.3.

Another crucial component of Lemke's work was examining how teachers and learners build up the patterns of conceptual relationships. To accomplish that, he engaged a method known as Thematic Analysis, which is a process of identifying specific science content and showing how its particular pattern of conceptual relationship is being successively constructed and repeated across the dialogue. This pattern of conceptual relationships according to Lemke is a Thematic Pattern. A thematic pattern outlines "a shared pattern of semantic relationships…what many different ways of saying the same thing have in common" (Lemke, 1990, p. 87). In other words, it is a way of picturing connections occurring among the meanings of scientific concepts in a given field of study. He adds that, when teachers and learners construct a thematic pattern, they present a network of relationships among the scientific concepts, that are described semantically (in a way that relates to the different meanings of words) based on how language is used in a particular field. Hence, the Thematic Pattern of a Discourse is constructed from the semantic relationships created during the Discourse.

Through analysis of several episodes of lessons, Lemke (1990, p. 37) identified 'thematic items' such as 'HEAT', LIGHT and 'ENERGY' shown in Figure 4.2. He then used the rules of semantics to identify the different forms of semantic relationships occurring among the identified thematic items that could be presented in a Thematic pattern. Examples of semantic relationships include nominal relationships occurring between two thematic items in the form of synonyms, antonyms, hyponyms, classifiers, or locations. Another example is the circumstantial relationship occurring between a thematic item and its location, time, manner, or reason. Figure 4.2 below shows an example of a thematic pattern constructed by Lemke from one of the lesson episodes that he analysed.

GROUND	CREATE	*Agent/Process*
GROUND	ABSORB	*Agent Process*
SUN	CREATE	*Agent/Process*
GROUND	SUN	*Location*
SUN	SEND	*Agent/Process*
SEND	LIGHT	*Process/Goal*
LIGHT	ABSORB	*Process/Goal*
LIGHT	CREATE	*Process/Material*
LIGHT	HEAT	*Classifier/Thing*
LIGHT	ENERGY	*Classifier/Thing*
HEAT	CREATE	*Process/Goal*

Figure 4. 2: Thematic pattern adopted from Lemke (1990, p. 37)
NB Words in italics represent the semantic relations between the thematic items in caps

Figure 4.2 shows the thematic items identified by Lemke (GROUND, CREATE, HEAT, ENERGY, LIGHT, ABSORB, SEND and SUN) and the semantic relationships found among them. It shows that the thematic item GROUND is related to the thematic item CREATE through an Actor/Process while the thematic item CREATE is related to the thematic item HEAT through a Process/Goal relationship. The thematic item HEAT is in turn related to the thematic item ENERGY through a Classifier/Thing relationship the thematic item HEAT is also related to the thematic item LIGHT through a Classifier/Thing relationship. The thematic item LIGHT is related to both ABSORB and SEND through a process/ Goal relationship. The thematic item SUN is related to both SEND and CREATE through an Actor or Agent/Process relationship. The thematic item SUN is also related to the GROUND through a Location relationship. Finally, the thematic item GROUND is related to the thematic item ABSORB through an Actor or Agent/Process relationship.

In summary, Lemke (1990) argues that the talk occurring in any science classroom is associated with two patterns viz., an organisational pattern represented by its activity structure and a thematic pattern. He maintains that firstly, in a science classroom, the teacher and learners interact with each other through moves as they are guided strategically by a given set of expectations about what may happen next. Secondly, as they interact in a science classroom, meanings about a given topic are constructed as they combine words and other symbols (thematic pattern). Based on Lemke's work discussed above, I identified four themes which were used as categories during the coding process. These categories which are Science Talk Text, Interaction Patterns and Teacher Discourse Moves, Teacher Discourse Strategies, as well as Thematics are shown in the coding system presented in Table 4.3. These categories were validated by giving an independent researcher who is familiar with biology ten pages of one of Mrs Durand's Lesson Observation 1 transcripts for coding. In addition to the ten pages of the transcript, I provided the researcher, with the coding scheme (Table 4.3) and discussed how I expected him to code. Once the independent researcher was done with coding, we established the report percentage agreement and resolved the difference by discussion.

Table 4. 3: My coding scheme

Categories	***Sub-categories***	***Coding groups***
1 Science Talk Text	Episode	
	Talk Turns	
2 Interaction patterns & teacher Discourse moves	Communicative Approach	Interactive /dialogic
		Non-interactive/dialogic
		Interactive/authoritative
		Interactive/authoritative
	Patterns of Discourse	I-R-E/F
		Chain interaction I-R-P-R-P-R- OR I-R-P-R-P-R-E
	Teacher Discourse Moves	Eliciting
		Marking
		Building

Categories	***Sub-categories***	***Coding groups***
		Other
3 Teacher Discourse Strategies	Thematic development strategies	Monologue strategies
		Dialogue strategies
	Teacher strategies for social interaction	Structural control strategies
		Thematic control strategies
	Multimodal representations	Gesture representation strategies
		Verbal representation strategies
		Visual representation strategies
4 Thematics	Locus of Thematic Development	
	Thematic Items	
	Semantic Relations (Thematic patterns)	

Adapted from Lemke (1990); Scott and Ametller (2007)

Table 4.3 above shows four categories drawn from Lemke (1990) and their sub-categories. For a definition of terms used in this section and analysis in general refer to Table 2.2 in Chapter 2. The first column in Table 4.3 headed TEXT is the category that identifies the episode, line number and talk turns in the original classroom observation transcript. The episode sub-category collates a group of talk turns around a similar topic.

The second category is INTERACTION PATTERNS and TEACHER DISCOURSE MOVES. In terms of interactive patterns, the category coded for Communicative Approach, and Patterns of Discourse sub-categories. Firstly, the Communicative Approach was used to code the approach engaged by the teacher such as interactive/dialogic, non-interactive/dialogic, interactive/authoritative, or non-interactive/authoritative. The second sub-category Patterns of Discourse was used to code the alternative forms of triadic Discourse evident in the lesson, for instance, I-R-E, I–R–F, chain interaction I–R–P–R–P/E. The teacher Discourse move formed the third sub-category of this theme which is coded for teacher-specific Discourse moves. For instance, probing for explanation or further participation, asking learners to restate someone else’s reasoning, or asking learners to apply their reasoning to someone else’s reasoning, revoicing, using waiting time, inviting student participation, use of pause, nomination of the learner, teacher evaluation and teacher elaboration.

The third category, TEACHER DISCOURSE STRATEGIES was used to code for teacher strategies which were further divided into three groups: thematic development strategies, social interaction strategies, and multimodal representation strategies. The thematic development strategies were further divided into monologue and dialogue strategies. Monologue strategies were coded as backgrounding and foregrounding, narrative, logical exposition, and selective summary while dialogue strategies were coded as joint construction, teacher question series and external text dialogue. The sub-category consisting of social interaction strategies was further divided into two groups: structural control strategies and thematic control strategies. Codes for structural control strategies included controlling the pace, signalling boundaries, admonition, and interrupting learners while codes for thematic control strategies included marking importance, marking old information, marking new information and regulating difficulty. The third sub-category considered multimodal representation strategies which were further divided into three groups: gesture representations, verbal representations, and visual representations. The codes used for coding gesture representations included hand pointing the board/slide/transparency, holding hands, hugging learners, movement towards learners, pointing learners, smiling/ laughing, using body and hands. Verbal representations were coded in terms of symbols such as letters TT or tt to represent genes. Lastly, visual representation strategies included notes on the board/slide/transparency, images on the board/slide/transparency, analogy, exemplification, role play, symbols and worksheets.

The fourth category THEMATICS, identifies the following sub-categories: Locus of Thematic Development or types of thematics, Thematic Items, Semantic Relations or Thematic Patterns evident in the specific text/talk turns. Where the Locus of Thematic Development was used to code for the type of thematics was evident according to who generated the thematics for instance, Joint Thematics, student Thematics, Teacher Thematics or External Text Thematics. Thematic items are coded for the science terms evident in the text while semantic relations are coded for the different types of relationships occurring among thematic items such as Synonyms/Antonyms, Item/Elaboration, and Processes/Targets. When connected, Thematic Items result in Semantic Relations which when combined would produce Thematic Patterns.

The analysis of data (lesson observation and interview transcripts) was deductive (Azungah, 2018) since I started the process with pre-defined codes and categories (Table 4.3). Nonetheless, I was open to any other interesting aspects of Discourse that could emerge from the data. For instance, Interesting aspects were also uncovered in this study in the Interaction Pattern category, where learners responded through noise and the teacher gave feedback in the I-R-F interaction structure. In addition, in the same interaction structure, the teacher asks questions, allowing for waiting time but learners do not respond, and the teacher responds to her questions.

4.6.2 Dividing lesson transcripts into episodes

The focus of this study is more on meaning rather than teachers' actions or responses. As a result, each lesson was divided meaningfully into episodes based on certain genetics concepts or sub-concepts that were being discussed by the teachers. I considered an episode as starting from a place where the teacher introduced a concept and focused on it to completion. In doing so, I focused on the teachers' use of language in terms of signposts, phrases such as 'next we will look at…', 'Let us move on…', Now, we are going…' etc. This process of dividing the lesson into episodes was validated by an independent researcher in the field of biology who divided one lesson transcript and obtained episodes that were similar to mine based on the criteria provided above. The excerpt below shows what the independent researcher considered (turn 198 in green) to divide part of the lesson transcript into episodes (see Appendix C14 for the fully validated Lesson Observation Transcript)

194.	*So, you need to know the terms please, again the topics are not isolated topics.*	
195.		*One follows the other,* *…there is a pattern that you will see [pause] ALRIGHT.*
196.		*Can I wipe this off?*
197.	*Ls:*	*Yes!*
198.	*Mrs. Durand:*	*↑We are now going to focus on the terminology that we need for meiosis, some of which will be similar here, but I am going to give the actual term and the definition.*
199.		*Please make sure that you copy this DOWN.*
200.		*Incidentally before the bell goes, my class tomorrow we have an afternoon lesson, ALL your DNA …worksheets will be marked tomorrow afternoon.*
201.	*Ls:*	*[Complaining]*
202.	*Mrs. Durand:*	*You better have them ready for tomorrow afternoon.* *[Learners making noise]*
203.		*I did not tell you to talk, the fact that I turned around does not mean you talk. [Pause]*
204.		*Okay, our terminology that we are going to use—is first— I am going to write them in order.*
205.		*Diploid which I already mentioned [pauses as she writes on the board] Okay, so this is meiosis terminology [writing on the board].*

4.6.3 Defining the unit of analysis for this study

A unit of analysis may be composed of one or a chain of continuous statements (Seah & Silver, 2020). In this study, the unit of analysis for lesson observations was an episode. Though lessons in this study were divided meaningfully into episodes, not all episodes contained science talk.

Hence, the episodes used for analysis in this study were supposed to meet the following criterion. Firstly, the episode was supposed to consist of an utterance or utterances that indicated the presence of a statement of science or a question about science terms or concepts. Secondly, the part of science (linguistic item) was supposed to be highlighted by another part of speech that called for attention to this item or provided explicit reference to the linguistic item or part of science. Thus, the unit of analysis in this study was an episode with an utterance that focused on and highlighted a particular aspect of a genetic linguistic item. This unit of analysis uncovered the following aspects of my sub-research questions (presented in section 4.4.1.): (a) the Locus of Thematic Development, Thematic Items, and Semantic Relations. Both Thematic Items and Semantic Relations together constructed Thematic Patterns (b) Interaction Patterns & Teacher Discourse Moves. (c) Teacher Discourse Strategies. Therefore, in this study, an episode that fulfilled the criteria above was referred to as 'Discourse Episode'. A Discourse Episode in this study is an episode with an utterance that focuses on and highlights a particular aspect of a genetic linguistic item and uncovers the four aspects of Discourse discussed above as shown below.

Example of a Discourse Episode (unit of analysis)

EPISODE 9: METAPHASE

133.	*Mrs. Durand*	*What was the next phase?*
134.	*Ls:*	***Metaphase!***
135.	*Mrs. Durand:*	*Right, what is going to happen in **metaphase?***
136.		*Okay [pauses as she writes on the board] in **metaphase**, those **chromosomes** if I am going to draw these things here, those **chromosomes** are going to lie on THE [pause]centre plate.*
137.		*[Writing on the board] What do we call this plate?*
138.		*THE [pauses] **equator,** is the **equator** of the **cell.***
139.		*In other words, in the middle of the cell.*
140.		*Think of how the cell is being earth, with the equator separating us into two halves.*
141.		*The SPINDLES are going to attach to the centro—[pauses] –meres, like that. [drawing on the board]*
142.		*Okay [writing on the board] so, your chromosomes aligning on the equator [pause] meta- middle remember that meta- middle… alright, you all remember that now?*
143.	*Ls:*	*Yes!*
144.	*Mrs. Durand:*	*Okay, your chromosome on the equator…*

Non-example of a unit of analysis

EPISODE 2: MEIOSIS AND EXAMS

7.	*Khensani:*	*Mrs. Durand… [not her actual name]*
8.	*Mrs. Durand:*	*/Is this still tested in paper 1? / It is paper 1 and 2.*
9.	*Khensani;*	*Paper one*

10.	*Mrs. Durand:*	*GUYS*
11.	*Khensani:*	*/So we are not writing--/*
12.	*Mrs. Durand:*	*Both. This topic is tested in both paper 1 and in paper 2, it is one of the topics that is asked in relation to reproduction in paper 1 and of course nucleic acids in paper 2 and genetics.*

The example of a unit of analysis satisfied the condition of providing explicit reference to the linguistic item foregrounded 'metaphase' through extended speech which highlighted the key events taking place during the phase 'metaphase', using gestures and representations on the board. On the contrary, the non-example though 'meiosis' which is a linguistic item is mentioned nothing more is said about it in terms of what it is and how it occurs. Consequently, the non-example was not included for analysis in this study. The next section presents the analysis process adopted in this study.

4.6.4 The Process of Analysis

Like Lemke (1990), in this study analysis of lesson observation transcripts was done in two parts. Firstly, episodes were analysed to identify their interaction patterns and the specific teacher moves and strategies employed by teachers and learners in using the forms of Triadic Dialogue, Teacher-Student Debate and so on. Secondly, episodes were analysed semantically to uncover thematics (refer to Table 2.2 for definitions of terms): the locus of thematic development, semantic relations, thematic patterns of the science content and the typical thematic development strategies used by teachers during the teaching of basic genetics. To achieve this, the episodes consisting of science talk were coded according to the coding scheme presented in Table 4.3 where four key themes identified by (Lemke (1990) and Mortimer and Scott (2003) were used as categories for coding each lesson transcript.

Coding was also conducted in two phases. The initial phase of analysis involved manual coding using the coding system presented in Table 4.3. I did this to familiarise myself with the data as I generated broad categories about the patterns of activity structures, teacher-learner tactics and specific teacher moves that were evident during the teaching of basic genetics. Manual coding was conducted on Mrs Durand's Lesson Observation 1 from Dataset 1 considering all episodes that made explicit references to science talk or genetics terms and concepts. An example to show how manual coding on Mrs Durand's lesson observation 1 transcript was conducted is presented in Figure 4.3 below. Manual coding was done using the coding scheme in Table 4.3 and coloured pens as well as highlighters. The talk turns were coded by highlighting with a highlighter and the codes emerging from the turns were written on the margin with coloured pens similar to the highlighter. During the initial coding process, I also jotted down notes in pencil on the transcript about the emerging patterns which assisted me when writing findings chapters. A copy of such notes is presented in Figure 4.4.

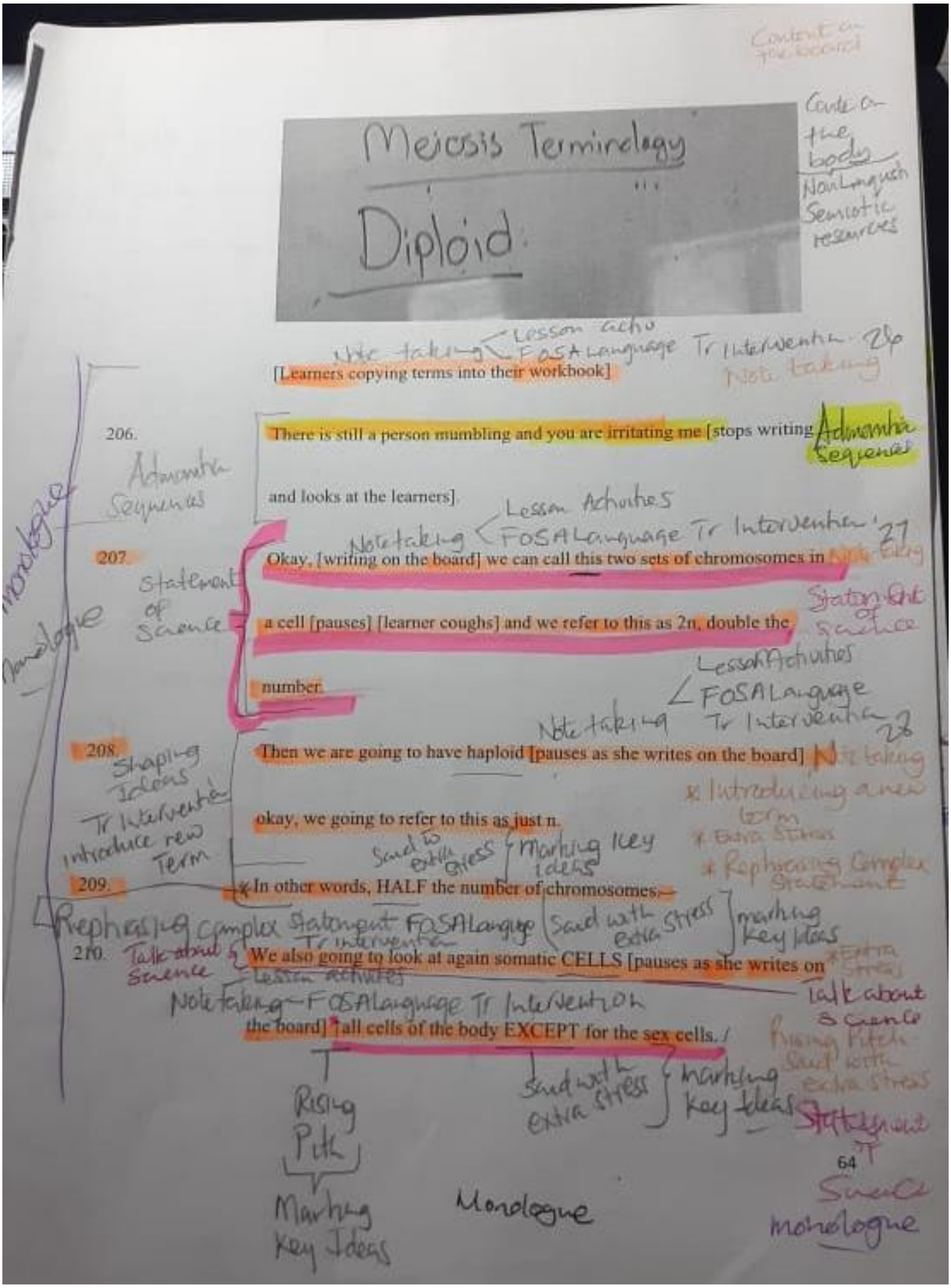
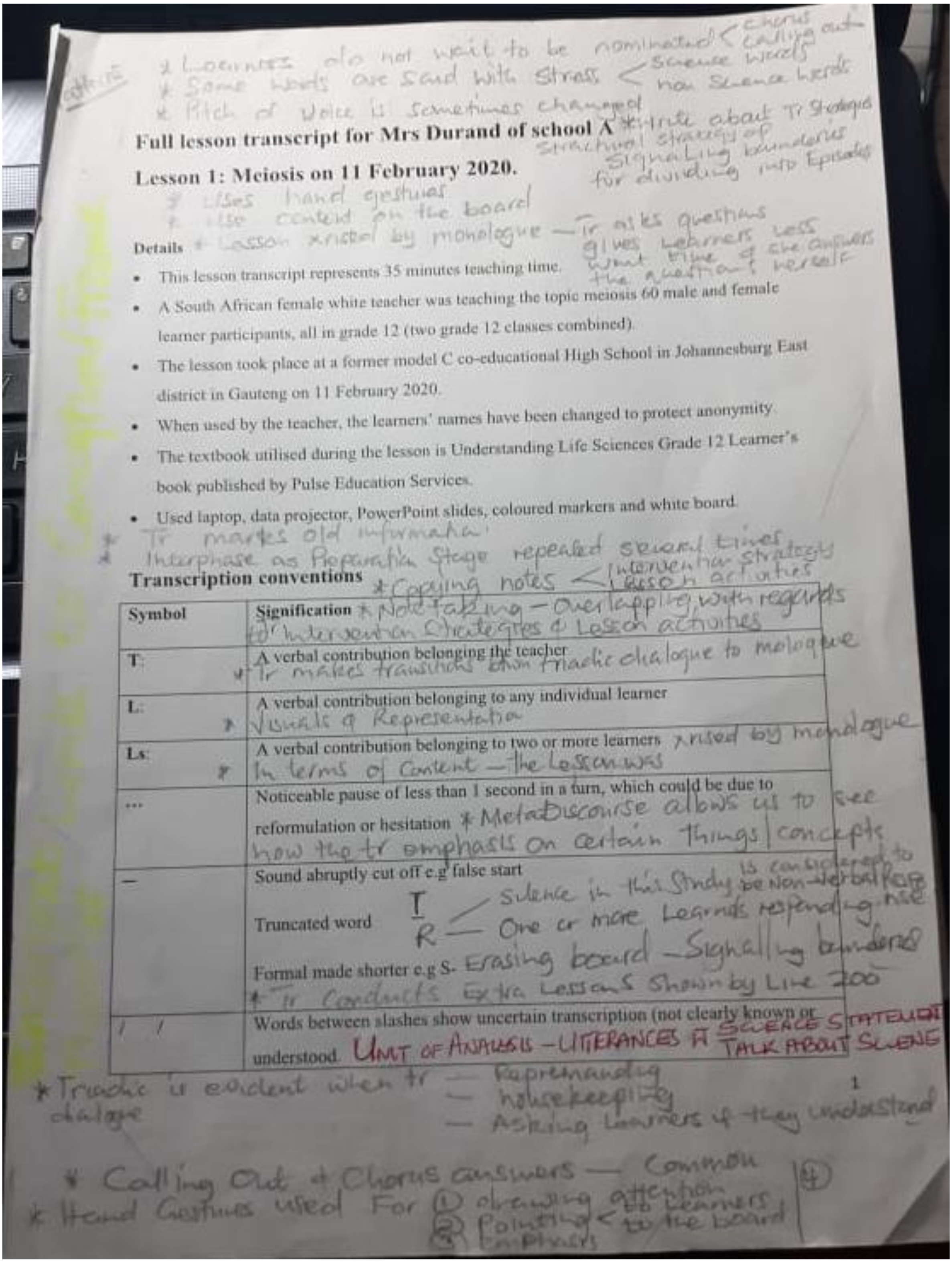


Figure 4. 3: Section of Mrs. Durand's lesson observation 1 transcript coded manually



* Learners do not wait to be nominated < Chorus / calling out
* Some words are said with stress < Science words / non Science words
* Pitch of voice is sometimes changed

Full lesson transcript for Mrs Durand of school A *Write about Tr Strategies / Structural strategy of signaling boundaries for dividing into Episodes

Lesson 1: Meiosis on 11 February 2020.

* Uses hand gestures
* Use content on the board

Details * Lesson xrised by monologue — Tr asks questions / gives learners less time & she answers the question herself

- This lesson transcript represents 35 minutes teaching time.
- A South African female white teacher was teaching the topic meiosis 60 male and female learner participants, all in grade 12 (two grade 12 classes combined).
- The lesson took place at a former model C co-educational High School in Johannesburg East district in Gauteng on 11 February 2020.
- When used by the teacher, the learners' names have been changed to protect anonymity.
- The textbook utilised during the lesson is Understanding Life Sciences Grade 12 Learner's book published by Pulse Education Services.
- Used laptop, data projector, PowerPoint slides, coloured markers and white board.

* Tr marks old information
* Interphase as Preparation Stage repeated several times

Transcription conventions

Symbol	Signification
T:	A verbal contribution belonging the teacher
L:	A verbal contribution belonging to any individual learner
Ls:	A verbal contribution belonging to two or more learners
…	Noticeable pause of less than 1 second in a turn, which could be due to reformulation or hesitation
—	Sound abruptly cut off e.g false start Truncated word Formal made shorter e.g S.
/ /	Words between slashes show uncertain transcription (not clearly known or understood.

1

* Triadic is evident when tr — Reprimanding — housekeeping — Asking learners if they understand
* Calling Out & Chorus answers — Common
* Hand Gestures used For ① drawing attention to learners ② Pointing to the board ③ Emphasis

Figure 4. 4: Example of notes jotted on the transcript during manual coding

After establishing the broad categories discussed above, Mrs Durand's Lesson Observation 1 was coded again together with the rest of the transcripts from Dataset 1 were recoded using ATLAS.ti. The procedure discussed above was repeated for Datasets 2 and 3. An example of the coding conducted using ATLAS.ti is presented in Figure 5.5 below. The second phase of coding also involved manual coding using the coding system shown in Table 4.3. This was done to generate a broad category about thematics that gets constructed through the locus of thematic development, semantic relations, and thematic patterns of the science content evident during genetics lessons.

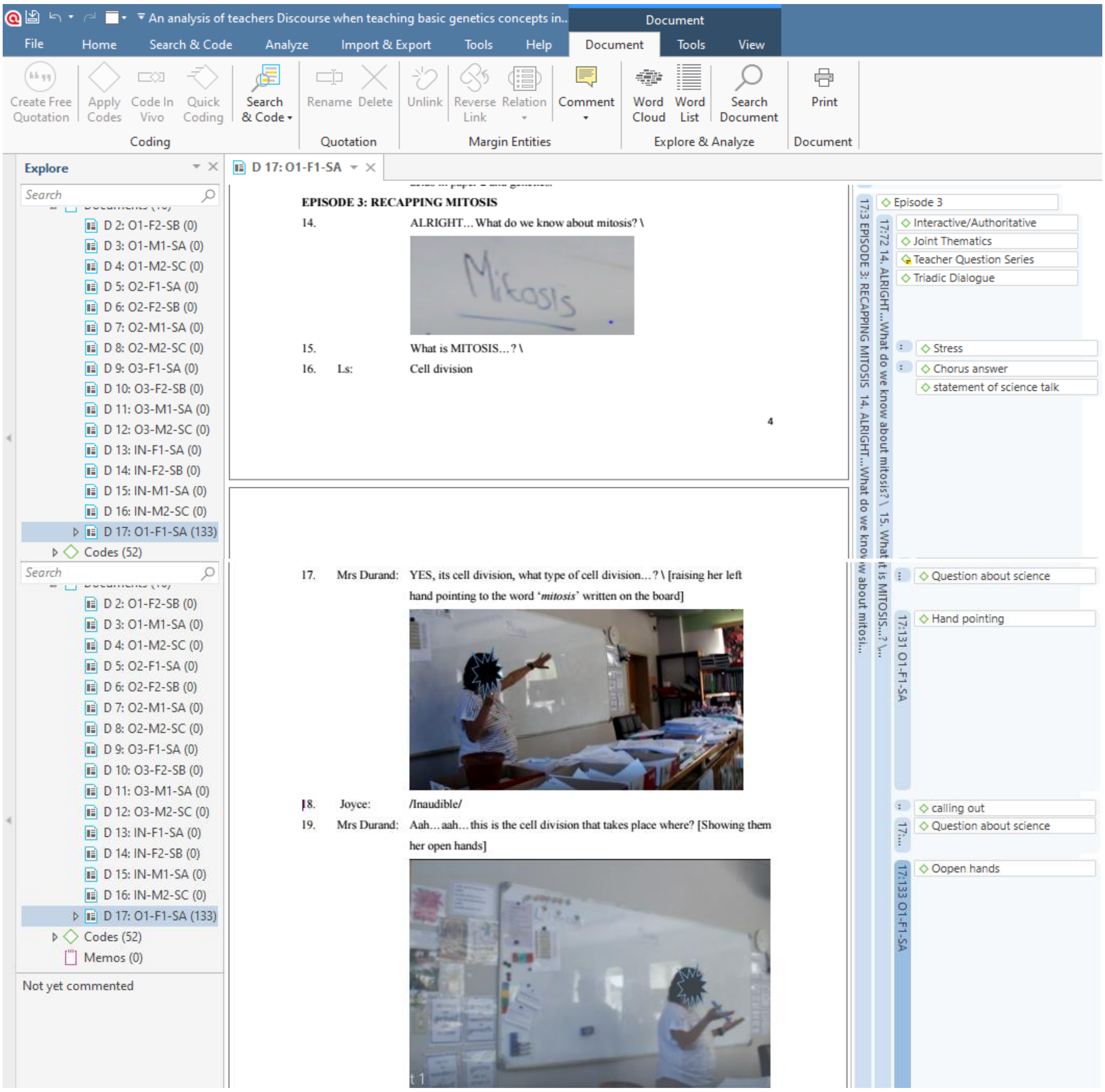


Figure 4. 5: An example of how coding was done using ATLAS.ti software

The next section presents the process of constructing Thematic Patterns.

4.6.5 Constructing Thematic Patterns

The final stage of phase two of analysis was the construction of thematic patterns per episode for each teacher's lesson observations. This stage was conducted to uncover the information that was required to address my first sub-research question which probed participant teachers' practices in terms of how they develop genetics concepts during the teaching of basic genetics to grade 12 learners. To construct thematic patterns for each participant teacher's observed lessons, I used work conducted by Lemke (1990). Not all classroom talk occurring in a science classroom is about science. In fact, not all episodes in the participants' lesson observations comprised of science talk. Owing to this, as described in section 4.6.2, the talk turns were separated using episodes.

Thus, episodes with talk about science were identified and from the talk turns that were coded under the "Thematic Item" category, a clause or a statement that contained thematic items or science concepts (semantic objects) was identified. The identified semantic objects were arranged sequentially per episode (the ones comprising science talk). Co-thematic semantic objects evident in each episode were also collated and re-phrased into fragments (a word, phrase, or clause detached from a sentence). A co-thematic semantic object in a stretch of talk may be verbatim repetition or repetition by modification. The example below shows how semantic relations that were constructed in the classroom during a lesson can be presented as a thematic pattern. The episode below is an example of an episode that fulfils the criteria for the unit of analysis discussed earlier. In this episode, the participant teacher (Mrs. Durand) was teaching a genetics theme 'Mitosis'. The thematic items (core science concepts) evident in Mrs Durand's discussion during this episode were identified and highlighted as shown in the episode below.

EPISODE 4A: MITOSIS

25.	*Mrs. Durand:*	*What is MITOSIS? [Pointing to the learners]*
26.		*[Writing on the board] It is a **cell division** where the **mother cell** undergoes (pause) **division.***
27.		*Okay and what is created?*
28.	*Ls:*	***Two identical—***
29.	*Mrs. Durand:*	*Now there is a term that we spoke about in grade 10…where we say two **identical daughter cells**.*
30.		*In other words, if I do **mitosis** like this… [writing on the board] alright and does anybody still remember what this refers to? [Silence]*
31.		*Okay, the **chromosome number** still stays the same here. [Silence, writing on the board]*
32.		*In other words, when we said in **mitosis**…the **chromosome number** stays the same in these two identical daughter cells.*
33.		*We refer to this as, being a **diploid chromosome number**.*
34.		*FULL NUMBER OF **CHROMOSOME**…does not change. *
35.		*Okay the **chromosome** number does not change, WHETHER you are a human or dog.\ …and it is in your **body cells**, what **cells are body cells**…?[pointing to the learners with marker]*
36.		*[Silence] **Somatic cells** ↑people [pause as she writes on the board].*

37.	*It occurs in the **somatic cells**, [writing on the board] in other words... the **cells** all over your body [using hands] EXCEPT in YOUR [pause] **sex cells**\ [using hands]*
38.	*↑OKAY [pointing to the board] so, remember that…okay, it stays **diploid**.*
39.	***Two identical daughter ↑CELLS** identical to the parent cell.*

Based on the way the highlighted thematic items (boldface) were connected in episode 4A, the following fragments were constructed and listed chronologically as shown below in Fragment 4.1. The type of semantic relations evident are highlighted and italicised. These semantic relations together give us a Thematic pattern.

Fragment 4 .1

- Mitosis [is] a type of cell division -MITOSIS=***hyponym**,* CELL DIVISION=***hypernym***
- Cell division [where] mother cell undergoes division ***Item/Elaboration***
- Cell division [creates] two identical daughter cells ***cause/consequence***
- In mitosis chromosome number [stays] the same ***Item/Elaboration***
- Chromosome number [stays] the same in identical daughter cells ***Item/Elaboration***
- Condition where chromosome number [stays] the same is diploid
- Diploid [is] full number of chromosomes ***definition***
- Number of chromosomes in cells does not change ***Item/Elaboration***
- During mitosis, chromosome number does not change whether you are a human or a dog ***Item/Elaboration*** (exemplification)
- Chromosome number does not change in body cells ***Location/located***
- Body cells [are] somatic cells ***synonym/synonym***
- Mitosis [occurs] in body cells ***location/located***
- Mitosis [occurs] in somatic cells ***location/located***

Located mitosis

Location body cells

- Mitosis [occurs] all over the body cells except sex cells ***Antonym/Antonym***
- Somatic cells stay diploid ***Classifier/thing***
- Two identical daughter cells are identical to parent cell ***identified/identifier***

Identified =two daughter cells

Identifier=identical to parent cell

The identified thematic items when connected give us the semantic relations which when combined give us the Thematic pattern. According to Lemke (1990), the process of mastering science requires mastery of subject-specific thematic patterns. However, thematic patterns in science education are usually left implicit and barely talked about. As a result, the science content becomes unintelligible. Furthermore, the difference between the science language and everyday language is unsettled (Lemke, 1990). Therefore, in this study, the thematic patterns were constructed to show how the meanings of genetics concepts are related to each other and what is relevant to talk about in a given situation during the teaching of genetics as teachers develop genetics concepts as well as distinguishing between everyday and science language.

4.7 Chapter Summary

In this chapter, sources of data were presented followed by a discussion on how data was prepared for transcription. The process of transcription adopted for this study was highlighted step by step. A discussion on how the data was prepared for further entry into ATLAS.ti software followed. This chapter then concluded with a discussion of how data analysis was conducted in this study.

CHAPTER 5: DEVELOPMENT OF GENETICS CONCEPTS DURING THE TEACHING OF BASIC GENETICS

5.0 Introduction

Presented in this and the two subsequent chapters, are the major findings of this study which are organized around each research question. As a reminder, this study sought to characterise the teachers' Discourse when teaching basic genetics in South African classrooms by addressing the following three sub-research questions:

1. ***How do teachers develop genetics concepts during the teaching of basic genetics to grade 12 learners?***
2. *What forms of interaction patterns and teacher Discourse moves are evident during the teaching of basic genetics to grade 12 learners?*
3. *What kinds of emergent teacher strategies can be extracted from the Discourse of teaching basic genetics to grade 12 learners?*

In this chapter, I present major findings for the four participant teachers (Mrs. Durand, Mrs. Letsiba, Mr. Zindi, and Mr. Zulu) in terms of the first sub-research question highlighted above. During this study, the four teachers taught the two topics 'meiosis' and 'genetics' to grade 12 learners.

In this study, analysis was influenced by my theoretical framework presented in Chapter 2, Figure 2.3. Since the overarching theory for this study was Gee's Theory of D/discourse, analysis was done in terms of language (genetics content) and the context in which language was used. My first sub-research question was intended to establish how teachers develop genetics concepts during the teaching of basic genetics to grade 12 learners. With this, I sought to understand how teachers use the language of science (genetics content) in their classrooms using three aspects of language viz, types of thematics, thematic items, semantic relations, and thematic patterns shown in Figure 2.3 (Chapter 2). Therefore, to address my first sub-research question analysis focused on these four aspects.

This study was primarily influenced by Lemke's seminal work on Thematic analysis contends that learning science means doing science and doing science is always guided and informed by talking science, hence, learning science means learning to 'talk science'. Therefore, the main goal of science learning for learners, according to Lemke, is to be able to 'talk science' to make meaningful connections across basic science concepts. In his seminal work, Talking Science, Lemke (1990) contends that while teachers may think they are teaching science 'concepts' what they generally do in the classroom is expose learners repeatedly to Thematic patterns. He further argues that for the most part 'concepts' are just Thematic items, and their customary semantic relationships are just bits of Thematic patterns. Below, I present an example of the concept (cell division) which was developed into a thematic pattern (Fragment 5.1) using the thematic items and the semantic relations constructed among them during Mrs. Durand's Lesson Observation 1. (The transcription conventions used in the transcript below and others to come are presented in Table 4.2 of Chapter 4.)

Episode 4A: Cell division

25.	Mrs. Durand:	What is MITOSIS? [Pointing to the learners]
26.		[Writing on the board] It is a **cell division** where the **mother cell** undergoes (pause) **division.**
27.		Okay and what is created?
28.	Ls:	**Two identical**—
29.	Mrs. Durand	Now there is a term that we spoke about in grade 10…where we say two **identical daughter cells**.
30.		In other words, if I do **mitosis** like this… [writing on the board] …alright and anybody still remember what this refers to? [Silence]
31.		Okay, the **chromosome number** still stays the same here hey. [Silence, writing on the board]
32.		In other words, when we said in **mitosis**...the **chromosome number** stays the same in these two identical daughter cells.
33.		We refer to this as, being a **diploid chromosome number**.
34.		FULL NUMBER OF **CHROMOSOME**…does not change. \
35.		Okay the **chromosome** number does not change, WHETHER you are a human or a dog.\ ...and it is in your **body cells**, what **cells are body cells**…? [pointing to the learners with a marker]
36.		[Silence] **Somatic cells** ↑people [pause as she writes on the board].
37.		It occurs in the **somatic cells**, [writing on the board] in other words... the **cells** all over your body [using hands] …EXCEPT in YOUR [pause] **sex cells**\ [using hands]
38.		↑OKAY [pointing to the board] …so, remember that…okay, it stays **diploid**.
39.		**Two identical daughter** ↑**CELLS** identical to the parent cell.

Mrs. Durand LO1 episode 4A

In light of the way the highlighted scientific terms otherwise known as Thematic items (boldface) were connected in episode 4A, the fragments constructed, and the semantic relations (thus Thematic pattern) established are presented in Fragment 5.1. The Locus of the Thematic development in the extraction above is Teacher Thematics which means that the teacher developed the semantic relations among the Thematic Items on her own without learner participation.

Fragment 5.1: Teacher Thematics and Semantic Relations Constructed in Mrs. Durand LO1 Episode 4A

Mrs. Durand:	**Mitosis** is a type of **cell division**- *Hyponym/Hypernym* **Cell division mother cell** undergoes division- *Item/Elaboration* **Cell division** [creates] **two identical daughter cells-** *process/target* In **mitosis chromosome number stays the same** *Quantifier/Thing* **Chromosome number** stays the same in **identical daughter cells-** *Quantifier/Thing* Condition where **chromosome number stays the same** is **diploid-** *Definition* **Diploid** is **full number of chromosomes**- *Definition* **Number of chromosomes** in cells does not change- *Item/Elaboration* During mitosis **chromosome number** does not change whether you are a **human or dog-** *Item/Elaboration* **Chromosome number** does not change in **body cells**- *Item/Elaboration* **Body cells** are **somatic cells**- *Synonym/Synonym* **Mitosis** occurs in **body cells-** *Location/Located* **Mitosis** occurs in **somatic cells**-*Process/Target* **Mitosis** occurs all over the **body cells except sex cells**- *Antonym/Antonym* **Somatic cells** stay **diploid**- *Item/Elaboration* Two identical daughter cells are **identical to parent cell**- *Item/Elaboration*

Thus, we never use these terms one at a time, but their usefulness comes from their connections to one another. So, it is the Thematic patterns that we need and create in a science classroom during teaching. Lemke (1990) refers to the pattern of connections among the meanings of words in a particular field of science as their Thematic pattern. It is a pattern of semantic relationships that describes the science content, of a particular topic. It is like a network of relationships among the scientific concepts in a field, but described semantically, in terms of how language is used in that field. Thus, talking science entails mastering a Thematic pattern of conceptual terminology in terms of their semantic relationships.

According to Lemke (1990), a Thematic pattern shows what many different ways of saying ‘the same thing’ have in common. It describes a shared pattern of semantic relationships. The example below is a paragraph on the concept of ‘cell division’ that I extracted from a grade 10 life sciences textbook (Sterrenberg & Fouche, 2013, p. 1.26) and the suggested semantic relations (Thematic patterns) in Fragment 5.2.

- There are two types of cells in the human body.
    - Somatic cells (body cells)

- Sex cells Gametes (female eggs or male sperm)

- The division of somatic cells, which results in growth is known as mitosis.
- During cell division, a mother cell divides to form two identical daughter cells.
- The two daughter cells are not only identical to each other but also, to the original mother cell. They have the same genetic material in their cell nuclei as in the nucleus of the mother cell.
- The process of cell division during which gametes are formed is known as meiosis.

The fragment below shows the semantic relations suggested by the textbook on the concept of cell division presented in the paragraph above.

Fragment 5.2: Semantic relations suggested by the textbook on the concept of cell division

- There are **two types of cells** in the **human body**. *Quantifier/Thing*
    - **Somatic cell** (body cells) *Item/Elaboration*
    - **Sex cells**/ *Item/Elaboration*
      Gametes *synonym/synonym*
      (**female eggs** or **male sperm**) *Item/Elaboration*
- The division of **somatic cells**, which results in growth is known as **mitosis** *process/target*
- During **cell division**, a **mother cell** *Item/Elaboration*
- divides to form two **identical daughter cells** *Process/Target*
- The two **daughter cells** are not only **identical** to each other *Identified/identifier*
- but also, to the **original mother cell** *Identified/Identifier*
- They have the **same genetic material** *Item/Elaboration*
- in their **cell nuclei** *Location/Located*
- as in the **nucleus** of the **mother cell** *Meronym/Holonym*
- The process of **cell division** during which **gametes** *Process/Target*
- are formed is known as **meiosis** *Hypernym/Hyponym*

The pattern above gets repeated at different points in the lesson, and from one lesson to another. It is the same pattern found in the textbook and the test or examination. It is the pattern that learners must master in order to 'talk science' acceptably on a particular topic like cell division. It is this pattern that they must use to reason their way through a problem on 'cell division' to give the expected answer on a test.

Overall, Lemke claims that when teaching science, teachers need to guide learners on how to 'talk science' to make meaningful connections between basic science concepts. Thus, based on my first research question, I sought to understand how teachers developed genetics concepts during the teaching of basic genetics to grade 12 learners. To do this, I explored how teachers together with their learners constructed the patterns of genetics' conceptual relationships in classroom dialogue. I focused on the following aspects: locus of thematic development (type of thematics), thematic items (science terms), semantic relations (relationships of scientific meanings to one another), and how those relationships are connected into Thematic patterns. An example of these was discussed in the excerpt and fragments discussed above. Since this study was conducted in a grade 12 life sciences context, I presented important instruments of the life sciences curriculum viz, the CAPS document, Examination Guidelines of 2021, Grade 12 life sciences examination past exam papers and their marking guidelines as well as the Annual Teaching Plan in Chapter 2 Section 2.10. In the next section, I present a discourse ('d') analysis of these documents to put my findings into context.

5.1 Contextualising my findings

5.1.1 Discourse analysis of CAPS document versus Examination Guidelines

In South Africa, grade 12 life sciences teachers are presented with various documentsincluding the National Curriculum Statement (NCS) Curriculum and Assessment Policy Statement (CAPS) the Examination Guidelines and Annual Teaching Plan (ATP). A discussion on the aims and purposes of these documents was presented in Chapter 2 Section 2.10. In this section, I analyse the CAPS document, Examinations Guidelines and ATP together with the past exam paper and its marking guidelines. I do this because I found these curriculum documents to be pivotal in providing a context which influences the teachers' Discourse during the teaching of genetics. Therefore, I analyzed these curriculum documents to place the findings (based on the three sub-research questions) of my study in context. In addition, I used the discourse ('d') analysis of the CAPS, Examination Guidelines and ATP documents as a form of triangulation for my study.

A closer look at the CAPS document and the Examination Guidelines shows that the discourse or the language that is used in the Examination Guidelines is completely different from the way the CAPS document is phrased which may imply reality versus vision. On the one hand, the CAPS document uses the discourse of the language of learning and is very specific about what learners are expected to do and also links the current concepts to those that the learner has done before. When introducing a strand, the CAPS document uses the discourse of learning such as *explore, establish links, understand, research, expose learners, enabling learners terms* and *concepts*. On the other hand, the Examination Guidelines document uses the discourse (language) of examinations, for instance when introducing a topic such as meiosis, it indicates the paper in which the topic will be examined and the marks that the topic constitutes in that paper. Furthermore, when listing down the concepts to be dealt with, the Examination Guidelines use the language (discourse) of examinations such as

'Define: mutation, gene mutation, chromosomal mutation.'

'Differentiate between:

- Haploid (n) and Diploid (2n) cells in terms of chromosome number
- Sex cells (gametes) and somatic cells (body cells)
- Sex chromosomes (gonosomes) and autosomes

With regards to the concept of 'monohybrid crosses' presented later in this Chapter in Section 5.5.3; the Examination Guidelines document emphasises the format for representing genetic crosses. The Examination Guidelines seem to have influenced Mrs. Durand and Mrs. Letsiba into becoming assessment-focused during their teaching as shown by the example presented in Section 5.5.3. This is supported by the following extract from Mrs. Letsiba's interview session about her teaching and examinations.

339 Mrs Letsiba: …but they are going to write the exams
341. And they have to know that if they say to them draw a table, they have to know how to draw a table because there is a free mark…
343. … for drawing of the table.
345. That is why I said to you that I am very strict in terms of marking.
347. Just to do what… to prepare them for their final examination.

Mrs. Letsiba, INT

Mrs. Durand and Mrs. Letsiba taught their learners the format for representing genetic crosses procedurally while Mr. Zulu and Mr. Zindi who were content development focused taught the same genetic cross conceptually. Generally, the Examination Guidelines document provide a list of aspects of the content that learners are expected to know and how learners are expected to answer questions in the examination. A typical example of this is shown by the presentation of the process of 'transcription' in the CAPS document and the Examination Guidelines where the former just states the content to be covered as 'transcription from DNA' while the latter provides the actual aspects to be considered. An example below (Figure 5.1) was extracted from the guidelines.

Protein synthesis	❑ The involvement of DNA and RNA in protein synthesis: • Transcription o The double helix DNA unwinds. o The double-stranded DNA unzips/weak hydrogen bonds break to form two separate strands. o One strand is used as a template o to form mRNA o using free RNA nucleotides from the nucleoplasm. o The mRNA is complementary to the DNA. o mRNA now has the coded message for protein synthesis.

Figure 5. 1: Extract from guidelines
(DBE, 2021a, pp 8)

This very explanation is the one expected from the grade 12 learners when they are asked the following question about the process of transcription.

QUESTION 2

2.1 The diagram below represents two processes that occur during protein synthesis.

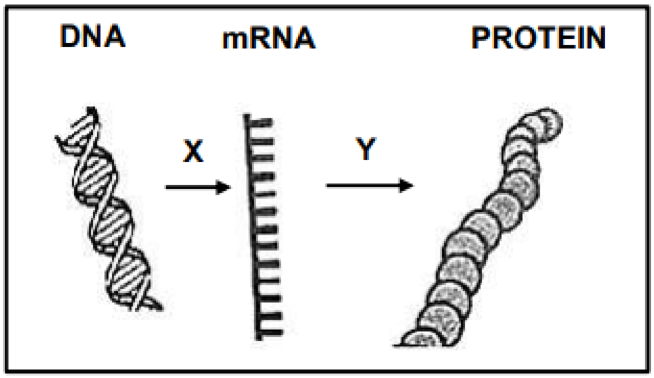


Figure 5. 2: Diagram showing Protein synthesis
(NSC Life Sciences November Examination 2021 English)

2.1.3 Name and describe process X *(6)*

Adopted from NSC Life Sciences November Examination 2021 English

Below is the expected answer according to the November Examination Marking Guidelines

*2.1.3 Transcription ✓**

- *The double helix (DNA) molecule unwinds✓*
- *The double-stranded DNA unzips/✓weak hydrogen bonds break - to form two separate strands*
- *One✓strand is used as a template✓*
- *to form mRNA✓*
- *using free RNA nucleotides from the✓nucleoplasm*
- *The mRNA is complementary to the DNA/✓A-U, G-C*

- *mRNA now has the coded message for protein synthesis*✓

**1 compulsory mark + Any 5* *(6)*

Adopted from NSC Life Sciences November Examination 2021 Marking Guidelines English

The presentation of concepts in the Examination Guidelines document which is similar to the expected response seems to tempt teachers to end up teaching their learners for examinations thus, becoming assessment-focused during their teaching. Though the Examination Guidelines document should be used in conjunction with the CAPS document for life sciences, life sciences teachers probably use the Examination Guidelines only when teaching in a bid to drill and prepare their learners for the final examination since schools are rated based on their grade 12 pass rates (Munsamy, 2014). It is, therefore, not surprising that the Discourse emerging from this study seems to be generally influenced by the Examination guidelines rather than the CAPS document. This study has shown that despite being interested in the development of concepts during their teaching, there are some cases where Mr. Zulu and Mr. Zindi seemed to be exam-oriented. This is quite acceptable as they would be doing learners a disservice if they did not prepare them for the examinations since they were required to write the National Senior Certificate Examinations at the end of the year. In the next section, I present the sources of data used for this chapter.

5.2 Data sources for this chapter

In this study, the main sources of data were the twelve lesson observation transcriptions which were generated from video recordings of a series of three consecutive lessons taught by each of four teachers to grade 12 learners during the teaching of basic genetics. As discussed previously in Chapter 4, detailed transcriptions of lesson observations were used to capture gestures, physical movements of teachers and learners, board work, and practical demonstrations. To augment the video data, other sources of data viz, post-lesson observation interviews and field notes were used for data triangulation purposes. This helped me to access teachers' rationale for taking certain actions during the observed lessons. Moreover, the interviews provided more information for answering the sub-research questions and enhanced the trustworthiness of my analysis as the various data collection methods complemented each other.

5.3 Method of Analysis

To analyse data for this chapter, as mentioned earlier, I started by identifying the episodes that consisted of an utterance/s that indicated the presence of a statement of genetics and/or question about genetics concepts in each of the teachers' lesson observation transcripts which I refer to as 'Discourse Episodes' in this study. My analysis for this chapter was influenced by a seminal study conducted by Lemke (1990) in science classroom Discourse. He used the method of Thematic analysis, the process where specific science content is identified and shown how its particular pattern of conceptual relationships (Thematic pattern) is subsequently built up and repeated throughout the dialogue. In this study, I adopted the same method to explore how teachers and learners constructed the patterns of genetics conceptual relationships during the teaching of basic genetics using the following aspects: locus of Thematic development, Thematic items, semantic relations, and Thematic patterns. These aspects are shown in the fourth category (Thematics) of my coding system presented in Table 4.3 in Chapter 4.

To code for the fourth category (Thematics in Table 4.3 in Chapter 4), I used three categories viz, Locus of Thematic Development, Thematic Items and Semantic Relations (Thematic Patterns). Locus of Thematic Development entails the type of Thematics evident according to who generated the semantic relations, for instance, Joint Thematics, Learner Thematics, and Teacher Thematics as discussed in section 4.6.1 in Chapter 4. The sub-categories, Thematic Items and Semantic Relations were used to fulfil the fourth sub-category of Thematics, which represents Thematic patterns. Therefore, for each episode that qualified as a Discourse Episode, I highlighted all the genetics terms that were used in that particular episode. I constructed fragments by arranging them chronologically (to show the thematic patterns) from the sentences that had highlighted genetics terms and presented them as fragments per Discourse Episode. I then established the semantic relations that existed between the highlighted genetics concepts from the way they were used in the episode. The following are the most common Semantic Relations observed from my data.

1. Nominal relation - attribute/carrier: when teacher or students described characteristics of organisms (For example, ***'Did you know that parents with blue eyes'…***) (*Mrs. Durand LO2 Episode 7 Line 162)*
2. Taxonomic relation – Part/whole or Subordinate/Superordinate: when the teacher gave examples of sex chromosomes (For example, '***These are the SEX chromosomes of an individual, that is either an X or a Y okay'.)*** (*Mrs. Durand LO1 Episode 14 Line 317*)

3. Transitivity relation - identified/identifier: when the teacher identified a relation (For example, *'...**we can call these two sets of chromosomes in a cell... and we refer to this as 2n'...***) (*Mrs. Durand LO1 Episode 14 Line 207*)
4. Circumstantial relation - process/reason: when the teacher explained why a process occurs (For example, '***is going TO replicate its genetic MATERIAL- Process/target for cell division to take place.***') (*Mrs. Durand LO1 Episode 14 Line 317*)
5. Logical relation - item/elaboration: when the teacher added or clarified a specific concept (For example, ***'It [interphase] is a preparation phase, that is why it is not part of the actual mitosis'.)*** (*Mrs. Durand LO1 Episode 7 Line 102*)

Lastly, identified Thematic Items and established Semantic Relations that formed Thematic patterns for each episode for the four teachers.

5.4 Types of Thematics evident in all four classrooms

The locus of Thematic development reveals the type of Thematics evident according to who generated the Thematics. Types of Thematics in a given science classroom may be in the form of Joint Thematics, Learner/s Thematics, Teacher Thematics, or External Text Thematics (Axelsson & Jakobson, 2020; Lemke, 1990). Joint Thematics are developed by both teacher and learners as they complete each other's utterances or respond to each other's questions during the Thematic development process, while teacher Thematics are developed by the teacher who is engaged in a Teacher Monologue (Axelsson & Jakobson, 2020). Learner/s Thematics are developed by either an individual learner or learners as they engage in dialogue with one another while External Text Thematics involve either a learner or the teacher reading the written text during the Thematic development process (Axelsson & Jakobson, 2020). In this study, the most predominant Thematics were Teacher Thematics followed by Joint Thematics. There were a few episodes that provided evidence of Learner Thematics and External text Thematics that were coupled with either Joint or Teacher Thematics in this study.

Table 5. 1: Locus of Thematic Development of the four teachers' lessons

Teacher	*Joint Thematics*	*Joint + External text Thematics*	*Teacher Thematics*	*Teacher + External Thematics*	*Joint + Learner/s Thematics*	*Total Thematics*
Mrs. Durand	2	0	18	4	0	**24**
Mrs. Letsiba	1	0	9	3	1	**14**
Mr. Zindi	10	1	9	0	0	**20**
Mr. Zulu	12	4	2	0	0	**18**
TOTAL	**25**	**5**	**38**	**7**	**1**	**76**

NB: Numerical values represent the number of episodes

According to Lemke (1990), the main role of science education is to teach learners how to use language according to the Thematic patterns of science, flexibly and for their purposes. This means, at least, teaching them to 'talk science' during lessons, on tests/examinations, in talking their way through to the solution of a problem (aloud or to themselves), and in writing or speaking about issues to which science is relevant. Table 5.1 shows that thirty-three per cent of the Thematic patterns constructed in this study were pure Joint Thematics and most of them were constructed in Mr. Zindi's and Mr. Zulu's classrooms. This implies that both teachers took advantage of dialogue to build shared Thematic patterns to assist their learners to effectively 'talk science' unlike Mrs. Durand and Mrs. Letsiba. In this type of 'talking science' where the teachers, as the more knowledgeable others (Abtahi et al., 2017), support learners as they co-constructed the Thematics with their learners. Furthermore, this talk has the potential to assist learners with the mastery of Thematic patterns. This means being able to mobilise a system of relationships so they can talk their way through a given task (Lemke, 1990). In addition, the mastery of Thematic patterns assists learners in answering questions during tests or examinations since the questions asked must fit the semantic relationships or the Thematic pattern of a given topic area (Lemke, 1990). This finding about Joint Thematics being the predominantly second suggests that the teachers in this study created opportunities for their learners to learners to learn 'talking science' and thus the genetic Thematic patterns in question.

Lemke (1990) argues that while teachers might think they are teaching science 'concepts', what they are doing in the classroom is exposing students repeatedly to Thematic patterns and argues that for the most part 'concepts' are just Thematic items and their customary semantic relationships, that is, they are just bits of Thematic patterns. Table 5.1 further shows that thirty-nine percent of the Thematics constructed in this study were Teacher Thematics which implies that the teachers were exposing their learners to the Thematics. The current discussion and the one just above show how the teachers in this study balanced the process of exposing learners (Teacher Thematics) to new Thematic patterns and affording them opportunities to practise as they constructed Joint Thematics.

It is sad to note that there was only one episode that showed evidence of Learner Thematics in this study as shown in Table 5.1. This finding suggests that most of the learners in this study were not afforded enough opportunities to practise the construction of Thematic patterns on their own. This was a constraint in this study, in the sense that the role of science education is to teach and allow learners to practise ‘talking science’ by doing and talking with the community of people who talk science or who have already mastered the language of science (Lemke, 1990). The main goal of science learning for students, according to Lemke, therefore, is to be able to talk science to make meaningful connections across core science concepts on their own. However, the findings in Table 5.1 suggest otherwise which implies that the learners in this study were not afforded enough opportunities to talk science on their own for them to be able to make meaningful connections across science concepts. Moreover, according to Lemke (1990), Thematic patterns do not only show up in the classroom dialogue, they are also seen in tests or examinations in the form of a multiple-choice question, or as part of the answer to a short essay item. Thus, the answer to an essay question could be graded quite precisely by matching its Thematic pattern (learner’s) to the standard one written by the teacher. The teachers in this study could have created conducive environments for the construction of Learner Thematics by allowing learners to engage in group peer or whole class discussions where learners would do most of the talking while playing the facilitating role. Mrs. Letsiba’s classroom stood out in the sense that it was the only one where the teacher tried to allow her learners to construct a Thematic pattern on their own. This finding suggests that generally, teachers in this study did not create opportunities for learners to practise talking science by constructing their Thematics for future encounters such as tests or examinations. On being asked during her interview session, why she allowed her learners to ask each other questions and answer them on their own while she was quiet, Mrs. Letsiba had this to say:

255.	*Mrs Letsiba:*	*Ehh…this is very important to me ma’am.*
256.		*As I am saying that ehh… at the same time, I am forcing them to read.*
257.		*I am forcing them to study.*
259.		*You understand!*
261.		*Hence, I am saying ehh… I am running away ehh… from that ehh… teacher-centred ehh… approach.*
263.		*Also, learners, they need to be independent.*
264.		*So, I give them the space.*

266. *So, that is what I am doing.*

267. *I am giving them space, so that they, ehh… can learn and I am like ehh…saying to them that you know what… it is of no use that ehh… and I do that…*

Mrs. Letsiba INT

The excerpt above shows that Mrs. Letsiba strongly believed that allowing learners to participate in the construction of Thematic patterns on their own provided them space to learn and encouraged them to study. Furthermore, Mrs. Letsiba seemed to understand the importance of creating an environment that allowed her learners to practise 'talking science' as evidenced by the statement; *Hence, I am saying ehh… I am running away ehh… from that ehh… teacher-centred ehh… approach. Also, learners, they need to be independent. So, I give them the space.*

According to Lemke (1990), the Thematic pattern constructed by the teachers on their own or jointly with the learners is similar to the pattern found in the textbook as discussed earlier in section 5.1. It is this pattern that learners must master in order to 'talk science' in an acceptable manner on a particular topic. And it is the same pattern they must use to reason their way through a problem or give the expected answer on a test. Table 5.1 shows that there were some instances where External text Thematics were coupled with either Joint or Teacher Thematics. This finding suggests that the teachers in this study understood that the Thematic patterns that they constructed with their learners during their lessons were supposed to be the same patterns as the ones presented in the course textbook. As a reminder, a generic example constructed to show thematics in terms of thematic items, semantic relations and thematic patterns was discussed in section 5.1. With this discussion on the type of Thematics constructed per teacher in this study, the next step is to discuss the Thematics of the study by citing examples from each Thematic type.

5.4.1 Teacher Locus of Thematic Development Profiles

In this section, I present the teacher Locus of Thematic Development profiles. To come up with these profiles, I looked at the type of thematics data (section 5.4 Table 5.1) for each teacher and constructed 'maps' per teacher for this category. I identified combinations of constructed thematics through the teacher's Locus of Thematic Development 'maps' (Figures 5.3 and 5.4) then indicated the teacher types or teacher profiles for classroom Discourse which are discussed in the next sub-sections.

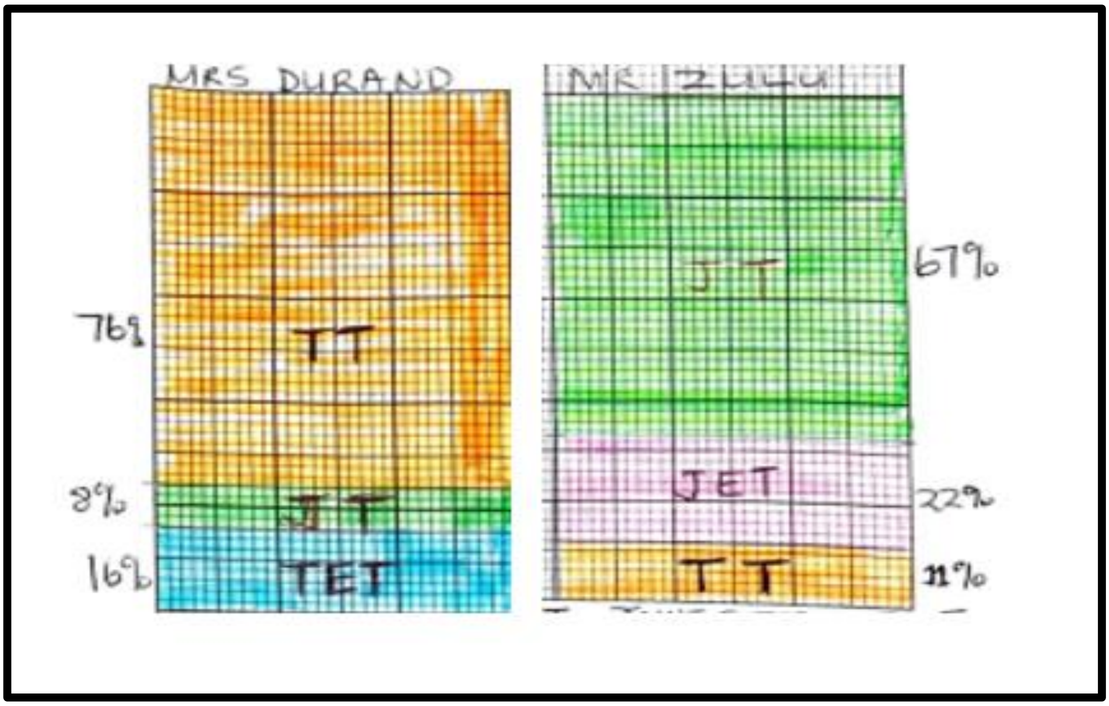


Figure 5. 3: Mrs. Durand's and Mr. Zulu's Locus Thematic Development Maps
Where: TT-Teacher Thematics, JT-Joint Thematics, TET-Teacher External Text thematics, JET-Joint External Text Thematics, JLT-Joint Learner Thematics

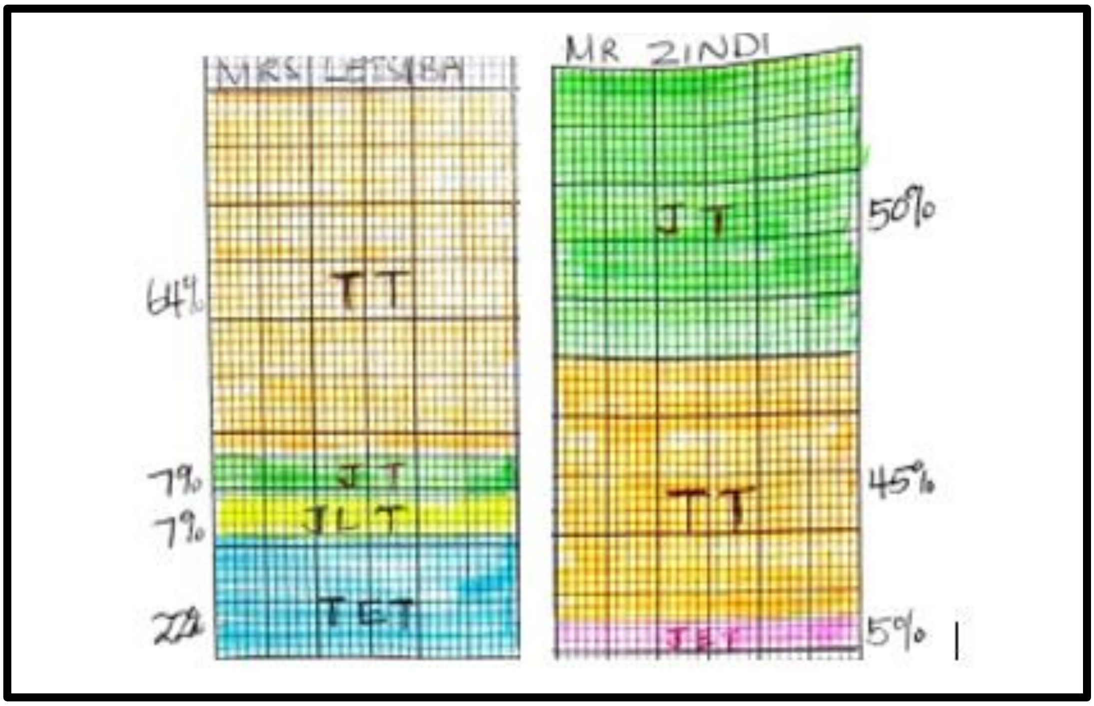


Figure 5. 4: Mrs. Letsiba's and Mr. Zindi's Locus Thematic Development Maps
Where: TT-Teacher Thematics, JT-Joint Thematics, TET-Teacher External Text thematics, JLT-Joint Learner Thematics

5.4.1 Mrs. Durand's Locus of Thematic Development Profile

Mrs Durand's Locus of Thematic Development 'map' (Figure 5.3) reveals her to be assessment-focused where her interest was on learners getting marks during tests and examinations rather than understanding the concepts. Her map shows that the majority of the Thematics constructed in Mrs. Durand's classroom were Teacher Thematics **(TT)**. The teacher focused on assessment as she constructed semantic relations thus Thematic patterns on her own without learner participation. There was no evidence of meaningful consolidation in Mrs. Durand's classroom. Instead, the classroom was associated with the teacher asking simple questions. These simple questions lead to the construction of a few Joint Thematics **(JT)** which were characterised by learners completing statements or clauses started by the teacher. In some cases, Mrs Durand constructed teacher Thematics coupled with External Text Thematics **(TET)** as she was drawing on external authority to construct the semantic relations. In this case, she consulted her notebook for definitions of terms. Overall, Mrs. Durand's practice was associated with the construction of more Teacher Thematics **(TT),** Less Joint Thematics **(JT)** and Teacher Thematics coupled with External text Thematics). Thus, this analysis uncovered the following.

MORE TT + LESS JT + TET = ASSESSMENT FOCUSED TEACHER

In the equation above MORE TT and LESS JT mean that the teachers who focused on assessment constructed more thematic patterns on their own than with their learners. TET means that these teachers on their own constructed Thematic patterns using external sources such as the course textbooks or notes.

5.4.2 Mr. Zulu's Locus of Thematic Development Profile

Mr Zulu's Locus of Development 'map' (Figure 5.3) reveals him as a content-focused teacher whose interest was in conceptual development. This is evidenced by the majority of the type of Thematics that were constructed in his practice which are Joint Thematics (JT). In his classroom, Mr. Zulu jointly constructed the semantic relations (thematic patterns) as he built conceptual understanding in dialogues using the **teacher question strategy** (discussed in detail in Chapter 7). To check his learners' understanding of the constructed semantic relations, Mr. Zulu consolidated by further constructing Joint External text Thematics where together with his learners drew from external authority for questions during revision sessions of homework or classwork. In addition, Mr. Zulu constructed Teacher Thematics, where he built semantic relations on his own as a way of consolidating the taught semantic relations. Overall, Mr. Zulu was portrayed as a conceptual development-focused teacher because he used more Joint Thematics **(JT)**, less Teacher Thematics **(TT)** and Joint Thematics coupled with External text Thematics **(JET).** Thus, the following was true for his practice.

MORE JT + LESS TT + JET = CONCEPTUAL DEVELOPMENT FOCUSED TEACHER

In the equation above, MORE JT and LESS TT mean that the teachers who focused on conceptual development constructed more thematic patterns with their learners than on their own. JET implies that these teachers together with their learners constructed Thematic patterns using external sources such as course textbooks or notes.

5.4.3 Mrs. Letsiba's Locus of Thematic Development Profile

Like Mrs. Durand, Mrs. Letsiba was portrayed as being assessment-focused with an interest in learners getting marks during tests and examinations. Mrs. Letsiba's Locus of Thematic Development 'map' (Figure 5.4) shows the majority of semantic relations (Thematic patterns) constructed in her classroom were Teacher Thematics **(TT).** In this case, the teacher constructed semantic relations on her own without learner participation in monologues using a **logical exposition strategy** (refer to Chapter 7 page 191 for more detail). It is clear from Mrs. Lesiba's Locus of Thematic Development 'map' that Mrs. Letsiba developed the concepts by constructing Teacher Thematics coupled with External Text Thematics **(TET)**. In this case, Mrs. Letsiba was seen drawing on external authority as she read from the course textbook. She probably wanted to construct semantic relations that were as close as possible to the course textbook. This practice which was also common in Mrs. Durand's classroom, provides conclusive evidence that these two teachers were interested in following the Examination Guidelines to the letter. It is, however, interesting to note that like Mrs. Durand's practice, there was no evidence of consolidation in Mrs. Letsiba's classroom. this finding suggests that the two teachers' interest was in developing the curriculum for tests and examinations rather than conceptual understanding. Moreover, like Mrs. Durand's practice, Mrs. Letsiba's was characterised by very little construction of **Joint Thematics**. These semantic relations were constructed by the teacher together with learners using simple questions or clauses that required learners to complete or answer through single-word answers. Despite being assessment development-focused, Mrs. Durand tried to allow her learners to construct semantic relations (thematic patterns) on their own. There was only one instance of this good practice in Mrs. Letsiba's practice and study as a whole. In this instance, Mrs Durand was seen allowing learners to construct Learner Thematics **(LT)** by building semantic relations on their own while the teacher acted as moderator. This analysis provides conclusive evidence that Mrs. Durand was an assessment-focused teacher. Overall, her practice met the following characteristics.

MORE TT + LESS JT + TET = ASSESSMENT FOCUSED TEACHER

5.4.4 Mr. Zindi's Locus of Thematic Development Profile

Mr. Zindi's Locus of Thematics Development 'map' (Figure 5.4) portrays him as a conceptual-focused teacher whose interest was in conceptual development. Forty-five per cent of Mr. Zindi's practice was characterised by the construction of Teacher Thematics **(TT)** where the teacher built semantic relations on his own without learner participation. He was seen building an understanding of conceptually on his own in monologues using strategies such as logical exposition (refer to Chapter 7). To check his learners' understanding of constructed semantic relations, Mr. Zindi through consolidation further constructed Joint Thematics **(JT)** where together with his learners constructed semantic relations (Thematic patterns). These Joint Thematics constituted the majority of the Thematics constructed in Mr. Zindi's classroom. Like Mr Zulu's practice, Mr. Zindi's was characterised by the construction of Joint Thematics coupled with External Text Thematics where the teacher drew on external authority for questions during the revision of constructed semantic relations. Overall, this analysis has portrayed Mr. Zindi as a conceptual development-focused teacher whose practice can be captured by the following.

MORE JT + LESS TT + JET = CONCEPTUAL DEVELOPMENT FOCUSED TEACHER

Ultimately, analysis of the four teachers Locus of Development has revealed two types of teachers viz, conceptual development teacher and curricular development teacher. In the next section, I present findings based on the thematic items and thematic patterns constructed by the teachers during the teaching of genetics.

5.5 The Development of Thematic Patterns

This study unveiled two types of teachers viz, Conceptual Development focused Teacher and Assessment focused Teacher. As a result, in this section, I present examples of the types of Thematics evident in four teachers' lessons by comparing the Thematic patterns that were constructed by these two kinds of teachers as they taught the following concepts that were common to all four classrooms; 'Gregor Mendel: The Father of genetics', 'gene', and 'monohybrid cross'. The common Thematics constructed during these concepts were Joint

Thematics **(JT)**, Joint Thematics coupled with External Text Thematics **(JET)**, Teacher Thematics **(TT)**, and Teacher Thematics coupled with External Text Thematics **(TET)**. An example of the types of Thematics was presented in Fragment 5.1 Section 5.0. New Thematic patterns were constructed when the teachers were introduced to the two topics of meiosis, and genetics. However, some of the Thematic patterns constructed in the subsequent lessons were not new though there were minor variations in terms of the context of talk where they were constructed and some of the thematic items used. In the next section, I present Thematics findings based on the two types of teachers that were uncovered in this lesson.

5.5.1 Development of Thematics

The four teachers in this study discussed 'Gregor Mendel: The Father of Genetics' in two different ways. On the one hand, Mr. Zindi and Mr. Zulu whose focus was on developing concepts taught this concept which was new to the learners step by step. They checked their learners' understanding through the **teacher question series** strategy in dialogues. On the other hand, Mrs. Durand and Mrs. Letsiba whose focus was on covering the curriculum presented in the Examination Guidelines taught the same concept in monologues but never consolidated the concepts to check their learners' understanding. Thus, in this section, I present the Thematic patterns constructed by Mr. Zindi and Mrs. Durand as examples from the two types of teachers (Conceptual Development focused and assessment focused respectively).

5.5.2 Dealing with Gregor Mendel: The Father of Genetics

Example 1

Conceptual Development of Thematics: Joint Thematics

When focusing on the concept of 'Gregor Mendel: The father of genetics', Mr. Zindi outshone all the other teachers in the sense that he used all the Thematic items suggested by their course textbook to build semantic relations and thus, Thematic patterns. However, Mr. Zindi used more Thematic items to build more semantic relations which were relevant to the concept under discussion. He focused on the concept of; 'Gregor Mendel: The Father of Genetics' by constructing the Joint Thematics shown in the exchanges below together with his learners. The words in bold are the Thematic items that Mr. Zindi used and the ones in upper case and italicised are the semantic relations which give us the overall semantic relations constructed. The following excerpt was extracted from Mr. Zindi's episode 4 of Lesson Observation 2 (LO2) where he was focusing on the concept of Gregor Mendel: The Father of Genetics.

Mr Zindi LO2: Gregor Mendel's work

175.	Mr. Zindi:	Whether it was about the colour of the **flowers**, he used **pure breeding plants** *ITEM/ELABORATION* that another keyword… [pointing to slide] and what is meant by **pure breeding**? [Silence] *DEFINITION*
176.		Using the previous example on the diagram.
177.		Can you understand from there, what does **true breeding** mean? *DEFINITION*
178.		Yes, Maria!
179.	Maria:	Sir, I think it is two **fertile mating partners**. *DEFINITION*
180.	Mr. Zindi:	Two **fertile mating partners**.
181.		That is not correct, thank you for your contribution.
182.	Khensani:	Sir let us say… / ? /.
183:	Mr. Zindi:	That is what he did, he **crossed** a **tall plant** and **a short plant**…he **crossed** them and produced **offspring.** *PROCESS/TARGET*
184.		He did the same with **purple** and **white plants**, but our challenge is all about what is it? *PROCESS/TARGET*
185.		When we talk of **pure breeding** or **true breeding pea plants** can you define these. Yes, Morrison!
193.	Stanley:	I think **true breeding** is the one that **breeds** naturally [inaudible and using hands] *DEFINITION*
194.	Mr. Zindi:	What I got from your answer and what I liked there is the use of the word **self-pollinate**…that will be **true breeding**. *ITEM/ELABORATION*
195.		Right, let us take for example before— okay you want to say something?
196.	Collins:	[With mask down] Sir, I wanted to say specific or particular tree whereby it **breeds** with another **true breeding organism** and then pass their **genes** to the coming generation. *DEFINITION*
197.	Mr. Zindi:	Right, let me go back to our diagram there, you see this type of—
198.	Ls:	Yes!
199.	Mr. Zindi:	[Showing]…**flower**…it belongs to a **plant** that only produces **purple…flowers** *MERONYM/HOLONYM* and this one produces **white flowers**. *MERONYM/HOLONYM* So, this **purple flowered plant** [pointing] is a **true breeding plant** provided it **self-pollinates**. *ITEM/ELABORATION*
200.		When it **self-pollinates**, it will always produce **purple flowered plants** and this one… [showing] if it **self-pollinates**, it will always produce **white plants**. *ITEM/ELABORATION*
201.		**Tall pea plants**, if they **self-pollinate**, they will always produce **tall plants**. *ITEM/ELABORATION*
202.		**Short plants** if they **self-pollinate**, they will always produce **short plants** [Showing] *ITEM/ELABORATION*
203.		We say this is **true breeding plant** and this one… [pointing] is also a **true breeding plant** right. *ITEM/ELABORATION*
204.		Meaning a **plant** is **true breeding** for a specific **characteristic** when it…when **self-pollination** takes place… [showing] all the **offspring** produced have the **same characteristics**… [showing] as the **parent plant.** *ITEM/ELABORATION*
205.		**Tall plant breeding tall plants**, **yellow flowered plants** breeding yellow plants right. *ITEM/ELABORATION*

Mr. Zindi LO2: episode 4

The excerpt provides evidence of learner participation (turns 179, 193, 196) during the construction of the Joint Thematics in the thematic pattern above. The teacher is seen eliciting definitions from learners (turns 175, 176, 185) while the learners contributed to the construction of the Joint Thematics by constructing a semantic relation known as Definition (179, 193, 196) as they tried to define the terms pure breeding and true breeding. This type of Thematics where learners are allowed to participate in the construction of Thematic patterns was also common in Mr Zulu's Classroom. This finding suggests that both Mr. Zindi and Mr. Zulu took advantage of dialogue to build shared Thematic patterns to assist their learners to effectively 'talk science'. This type of 'talking science' where the teachers being the more knowledgeable others (Abtahi et al., 2017) support learners as they co-constructed the Thematics with their learners and have the potential to assist learners with the mastery of Thematic patterns. This means being able to mobilise a system of relationships so they can talk their way through a given task (Lemke, 1990). In addition, the mastery of Thematic patterns assists learners answering questions during tests or examinations since the questions asked must fit the semantic relationships or Thematic pattern of a given topic area (Lemke, 1990). The example below shows how the taught Thematic patterns are related to questions in tests or examinations is shown below. It is an extract from the same episode as the one above where Mr. Zindi was teaching the same concept as 'Gregor Mendel: The Father of Genetics.

Mr. Zindi LO2: Gregor Mendel's work

109.	Mr. Zindi:	So, what he did…he removed the **stamens** from the **purple flower,** and it was only left with the **stigma**. *PROCESS/TARGET*
110.		Remember the **stamens** are the ones that produce **pollen grains**. *ITEM/ELABORATION*
111.		These are the male parts of the **flower,** and the **stigma** is the female part of the **flower**. *MERONYM/HYPONYM*
112.		So, all the **stamens** were removed from the **purple flower**. *ITEM/ELABORATION* [pointing].
116.		Why did he remove the **male organs**? [Silence] *ACTION/MOTIVATION*
117.		If we take all the boys in this class and we cut off their **male organs…** *ITEM/ELABORATION*
118.	Ls:	[Laughter]
119.	Mr. Zindi:	…what is going to happen?
120.		Are they going to be able to **reproduce**? *ITEM/ELABORATION*
121.	Ls:	No!
122.	Mr. Zindi:	No! So, why did he remove the **male organs** there?
123.		To prevent what? *ACTION/MOTIVATION*
124.	Collins:	**Fertilization**.
125.	Mr. Zindi:	To prevent **fertilization**… **fertilization** comes after **pollination** in **plants**, you remember that. *ACTION/MOTIVATION*
126.		So, he was trying to avoid or prevent **self-pollination**. *ACTION/MOTIVATION*

Mr. Zindi LO2, episode 4

The interesting example above occurred when Mr. Zindi was trying to construct an Action/Motivation (turn 116, 122) type of semantic relation together with his learners. During this construction Mr. Zindi tried to find out from his learners why had to cut out the stamens from the flowers. In trying to do so he was seen further constructing yet another type of semantic relation called Item/Elaboration (turns 117, 120). Hence, he elaborated by using an example where he asked his learners what would happen if all the boys' reproduction organs were to be cut (turn 117). It is this kind of connection between semantic relations that Mr. Zindi made during the construction of Thematic patterns that made him stand out as a conceptually focused teacher. hen constructing the thematic pattern above Mr. Zindi used the following image (Figure 5.5).

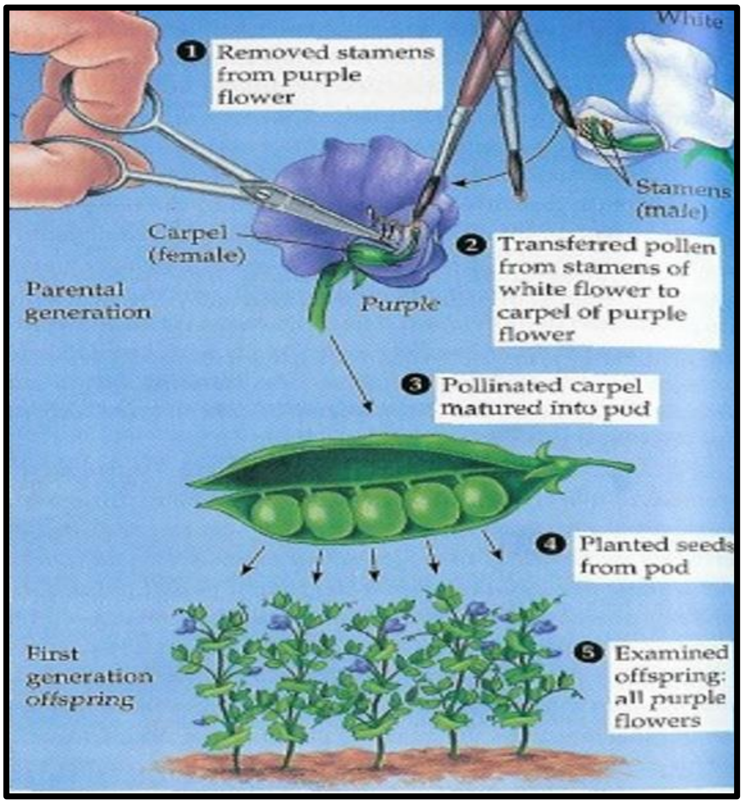
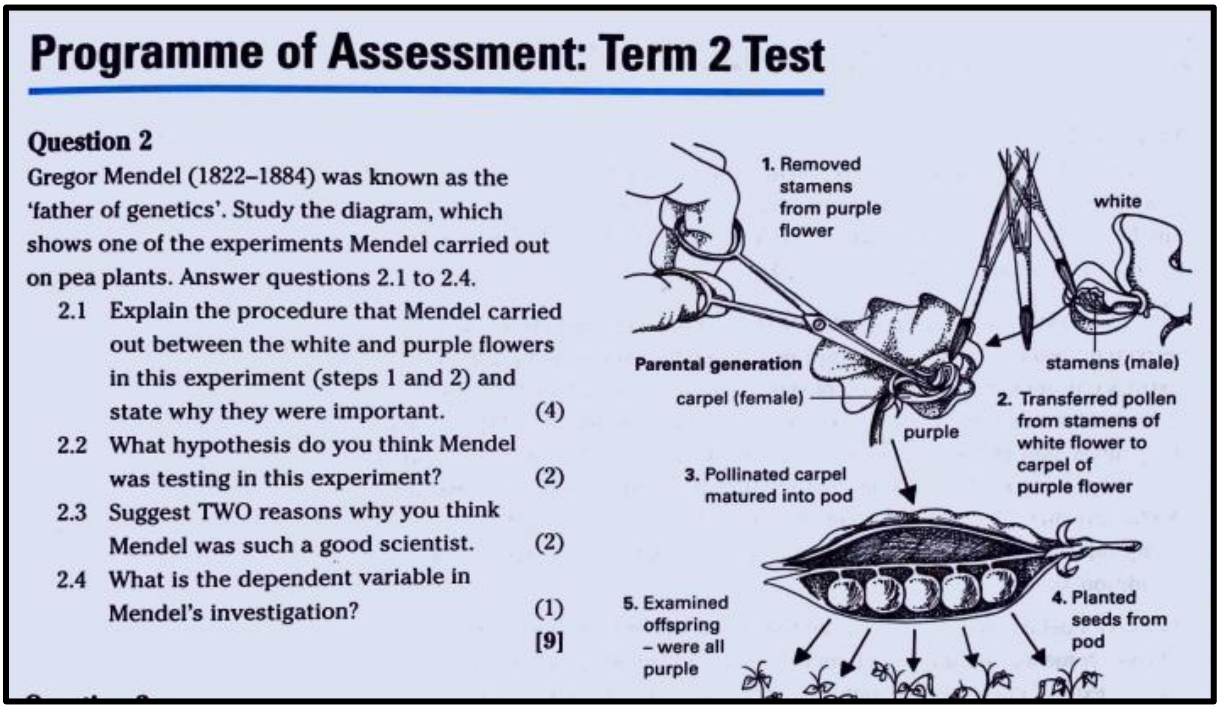


Figure 5. 5: Gregor Mendel's process
(Clitheroe et al., 2013)

Thus, the Item/Elaboration seems to be an associated type of semantic relation which assists teachers to clarify the meaning of terms or other semantic relations and provide learners with examples that enhance conceptual understanding. Figure 5.6 below shows questions from a test on the concept of 'Gregor Mendel: Father of Genetics'. It shows that questions require learners to use the mastered thematic patterns like the one constructed by Mr Zindi and his learners for them to be able to answer given questions in a test or exam.



Programme of Assessment: Term 2 Test

Question 2

Gregor Mendel (1822–1884) was known as the 'father of genetics'. Study the diagram, which shows one of the experiments Mendel carried out on pea plants. Answer questions 2.1 to 2.4.

2.1 Explain the procedure that Mendel carried out between the white and purple flowers in this experiment (steps 1 and 2) and state why they were important. (4)

2.2 What hypothesis do you think Mendel was testing in this experiment? (2)

2.3 Suggest TWO reasons why you think Mendel was such a good scientist. (2)

2.4 What is the dependent variable in Mendel's investigation? (1)

[9]

Figure 5. 6: Test questions on 'Gregor Mendel: The Father of Genetics'
(Clitheroe et al., 2013)

For learners to be able to answer question 2.1 for example, they should have mastered the Thematic pattern constructed by Mr. Zindi in the excerpt above on Mendel's work in turns 109-126 (the word 'turns' is explained in Table in 4.3 in Chapter 4). So, learners would need to understand mostly the Process/Target relations to be able to 'explain the procedure that Mendel carried out on purple and white flowers in this experiment…' and to be able to answer the second part of question 2.1 the learners should have mastered the Action/Motivation semantic relation.

The predominance of Joint Thematics in both Mr. Zindi's and Mr. Zulu's classrooms suggests that these teachers created opportunities for their learners to learners to learn 'talking science' with their support.

To teach his learners the concept of 'Gregor Mendel: The Father of Genetics', Mr. Zindi constructed twelve types of semantic relations[4] by liking sixty Thematic items that appeared to be related to the concept. Since he was introducing Mendel's contribution to the field of

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[4] Identified/Identifier, Item/Elaboration, Process/Target, Synonym/Synonym, Action/Motivation, Antonym/Antonym, Meronym/Hyponym, Attribute/Carrier, Agent/Process, Quantifier/Thing, Definition, Classifier/Thing

genetics, Mr. Zindi constructed a number of Process/Target relations where he focused on how Mendel conducted his experiments. For instance, how Mendel artificially pollinated his flowers using a paintbrush and how he cut the stamens of flowers to prevent self-pollination. The majority of semantic relations constructed in Mr. Zindi's Classroom were Item/Elaboration where he would introduce a term that is new to the learners and further elaborate on it through examples. Generally, Mr. Zindi elaborated on genetics terms as he tried to link them to Mendel's work by clarifying and providing learners with examples to assist them in going through conceptual understanding. Considering that Mr. Zindi used more Thematic items to construct more semantic relations than prescribed by the course textbook and constructed the Item/Elaboration semantic relations more than any other relation it follows that Mr. Zindi proved to be very creative and did not follow the textbook and the curriculum to the letter. These findings suggest that Mr. Zindi was interested in building conceptual understanding and was not bound by the curriculum, Examination Guidelines, or textbook.

Example 2:

Development of Thematics: Teacher Thematics

When focusing on the concept of 'Gregor Mendel: The father of Genetics', Mrs. Durand used thirty Thematic items (one of which was not relevant to the concept in question) to construct eleven semantic relations. She focused on the concept of; 'Gregor Mendel: The Father of Genetics' by constructing on her own, the Teacher Thematics shown in the exchanges below. Just as a reminder, the words in bold are the Thematic items that Mrs. Durand used and the ones in upper case and italicised are the semantic relations constructed which give us a Thematic pattern when combined. The following excerpt was extracted from Mrs. Durand's episode 3 of Lesson Observation 2 (LO2) where she was focused on the concept of 'Gregor Mendel: The Father of Genetics'.

Mrs. Durand LO2: Mendel's life history

71.	Mrs. Durand:	And he started working on **pea plants**…the pea that you eat.
72.		Those plants because they grow fast. *ACTION/MOTIVATION*
73.		They come in **two varieties**, basically, in the white and the purple *QUANTIFER/THING* he started **crossing** when he removed **stamens** of the one and he would **artificially pollinate**…the **pea plants**. *PROCESS/TARGET*
74.		He controlled it very strictly and then looked at the **offspring**. *PROCESS/TARGET*
75.		Now that time there was no word for **genes**. *IDENTIFIED/IDENTIFIER*
76.		Okay, they just knew that there was something was happening.
77.		It is only later this word of **genetics** was becoming a proper topic. *IDENTIFIED/IDENTIFIER*

78.	Here if you go back to like the early nineteen hundred right up to nineteen sixty, there was this race amongst **scientists** about who could map the **human genome** and that is when the whole thing about **DNA** all came into play. *TIME/EVENT*
79.	A lot of this work that we look at come from this man and that is why he is called '**Father of Genetics'** *IDENTIFIED/IDENTIFIER*.
80.	Whatever he did, all the laws he wrote out.
81.	There are three laws that you need to know but you will get to know them.
82.	What you do not know, do not think about it yet.
83.	You will see when we get to it okay.
84.	The three principles or laws that we still use today okay.
85.	So, okay this is basically what he discovered… …he discovered **heredity of plants** and as I said, his **experiments** *PROCESS/TARGET* were very well documented.
86.	That they could take his work, repeat, and get the same results because that is what a good experiment is all about.
87.	Ehm…he actually…now you know this hey, the **Doppler effect** *ITEM/ELABORATION*
88.	Ehm…he conducted his **experiments**.
89.	You, the science people should know what the **Doppler effect** is okay. *ITEM/ELABORATION*

Mrs. Durand LO2, episode 3

The episode above shows that the majority of the semantic relations constructed by Mrs. Durand while teaching the concept of 'Gregor Mendel: The Father of genetics' were Process/Target. She constructed the Process/Target relations to emphasise how Mendel performed his experiments that led to the discovery of the field of 'genetics'. This finding suggests that Mrs. Durand was assessment-focused interested in covering the content. Unlike Mr. Zindi and Mr. Zulu who were interested in building conceptual understanding by relating semantic relations like Process/Target to Item/Elaborating, Mrs. Letsiba's interest in Mendel's experiments rather than the concepts behind the processes.

All teachers in this study constructed the following semantic relations but differed in their frequency; Identified/identifier, Item/Elaboration, Process/Target, Attribute/Carrier, Agent/Process. They all constructed the identified/identifier semantic relation when they were introducing Gregor Mendel as the 'Father of Genetics' acknowledged his contribution to the field of genetics. Perhaps all four teachers constructed this semantic relation because as National Senior Certificate markers, they were aware that learners would be asked a question about this in the final examination. They all elaborated on terms but differed in the way they did it. Mr. Zindi and Mr. Zulu elaborated on items in a deeper way than Mrs. Durand and Mrs. Durand and Mrs. Letsiba who focused on just building semantic relations without connecting them and elaborating on them using more examples. The findings show that Mr. Zindi and Mr. Zulu were not bound by the Examination Guidelines but moved out of the box as they sought to build conceptual understanding in their learners. Mrs. Durand's interest in Mendel' process is supported by what she had to when asked why she referred to Mendel a lot in her teaching of genetics.

284.	*R:*	*You referred a lot to Mendel when you were teaching, what is the importance of doing this?*
285.	*Mrs Durand:*	*'Father of genetics' because whatever he did, we still use all these principles today.*
286.		*And I mean it was amazing for this man this man finding that there is something that determines what something will look like.*
287.	*R:*	*Ehm.*
288.	*Mrs Durand:*	*It is fascinating…I mean eighteen hundreds...*
289.	*R:*	*Ehm.*
290.	*Mrs. Durand:*	*…to now, how far it is gone from this…out of his little bit…his little garden.*
291.		*I have got a picture of his…where his pea garden used to stand at the monastery.*
292.	*R:*	*Ehm.*
293.	*Mrs Durand:*	*I show my kids that this is the place where he used to grow his peas.*
294.		*It is not a big place; it is quite a small area.*
295.		*Actually, if you take from where Amanda sits…*
296.	*R:*	*Ehm.*
297.	*Mrs Durand:*	*Right up to this chair.*
298.	*R:*	*Ehm.*
299.	*Mrs Durand:*	*That is the size of the plot.*
300.		*It is small…it is not a big area and yet he did all that work in that small place.*

Mrs. Durand INT

The excerpt above shows how Mrs. Durand strongly expressed the view about her interest in Mendel's work and how she wanted her learners to understand the process that Mendel went through to become 'The Father of Genetics'. The teacher's discussion about Mendel's work during the introduction of 'genetics' generates interest in the topic and development of science. Probably her interest in Mendel's work is the one that motivated her to construct more Process/Target relations at the expense of clarifying meanings of terms encountered during the construction of Thematic patterns.

5.5.2 Dealing with the concept of gene

Example 1

Conceptual Development of Thematics: Joint Thematics

Mr. Zulu dealt with the concept of genes using an example elicited from one of the learners. He focused on the concept of 'gene' by constructing the Joint Thematics shown in the exchanges below together with his learners. The excerpt below was extracted from Mr. Zulu's episode 3 of Lesson Observation 2 (LO2) where he focused on the concept of 'gene'.

Mr. Zulu LO2: The gene

40.	Mr. Zulu	So, let us say we are using one **characteristic** which **characteristic** would you like usto look at? Yes*? QUANTIFIER/THING*
41.	Lesedi:	Eye colour!
42.	Mr. Zulu:	Eye colour, right so which letters can be used to represent eye colour?
43.	Ls:	E.
44.	Mr. Zulu:	Okay, let us use B … let us use B it is okay right.
45.		So, we will use B to represent eye colour okay and…
46.		So, eye colour…what is an eye colour …is this a **gene** or an **allele?** *ITEM/ELABORATION*
47.	Ls:	[Chorus]
48.	Mr. Zulu:	Eye colour… is it a **gene** or an **allele**? *ITEM/ELABORATION*
49.	Ls:	It is a **gene**. *ATTRIBUTE/CARRIER*
50.	Mr. Zulu:	Why is it a **gene**? *ITEM/ELABORATION*
51.	Mr. Zulu:	Raise your hand. Yes? [Referring to a learner]
52.	Thembekile:	Sir it is a **gene** because…*ITEM/ELABORATION*
53.	Mr. Zulu:	Okay, so when we say for instance brown, green.
54.		Yes, that is correct!
55.		Or blue, red okay.
56.		So, those are alternative forms of this **gene**, the **gene** is eye colour. *DEFINITION*
57.		So, the eye colour and we said we are going to use a **B** as our **alleles** so let us say for instance the statement says in the exam. *ITEM/ELABORATION*
58.		Two **homozygous** parents for this type of **gene** which is eye colour which means they are **crossed** okay. *PROCESS/TARGET*
59.		If they are **homozygous** what does that mean? Yes? *ITEM/ELABORATION*
60.	Katlego:	I think they are doubles.
61.	Mr. Zulu:	They are doubles.
62.		What do you mean? Yes, chief?
63.	Lesedi:	**Genetically different**. *ITEM/ELABORATION*
64.	Mr. Zulu:	They are **genetically different**. No! *ITEM/ELABORATION*
65.	Thembekile:	Sir, there is a structure in the **genes** which is **genetically the same**. *ITEM/ELABORATION*
66.	Mr. Zulu:	**Genetically** the same. *ATTRIBUTE/CARRIER*
67.		No! Boys, did we do **homozygous** and **heterozygous** yesterday?
68.	Ls:	We did not do…
69.	Mr. Zulu:	Sorry!
70.	Jonah:	We did not do **homozygous**.
71.	Mr. Zulu:	We did do **homozygous** yesterday chief.
72.		**Homozygous**…yes? [Referring to a learner]
73.	Katlego:	Yes, they are the same sir.
74.	Mr. Zulu:	They are the same, okay **heterozygous** meaning they are different. *ITEM/ELABORATION*
75.		Right so, I will give you two **alleles** here…this an **allele** for let us say brown eye colour we said we going to use B okay so will use we will do brown and green right. *QUANTIFIER/THING*
76.		So, let us say this is …brown eye colour …and this said to be **homozygous**. *ATTRIBUTE/CARRIER*
77.		Why is it **homozygous**? *ITEM/ELABORATION*
78.		Because this-- these are capital letters; they are the same.
79.		But in this case whereby we have a capital letter and a small letter.
80.		Then what does this mean?
81.		This is **heterozygous** [showing letters on the board]…because this is capital letter and a small letter and remember this is representing **alleles** now okay. *ITEM/ELABORATION*
82.		We are looking at this person, what are the **alleles** that make up this person's **eye** colour. *ITEM/ELABORATION*

83.	Okay, we were saying this is **homozygous** and this is heterozygous *ATTRIBUTE/CARRIER* but the eye colour that we are going to choose here, we are going to say these two parents are…they are… they both have brown eyes, they both have brown eyes okay.
84.	But in this case …this one is **homozygous** for **brown eyes** and this one is **heterozygous** for **brown eyes**. *ATTRIBUTE/CARRIER*
85.	Remember a capital letter is said to be **dominant** but if it's a small letter then it is **recessive**. *ELABORATION*

Mr. Zindi LO2, episode 3

The excerpt above shows how Mr. Zulu developed the concept of 'gene' inductively using an example elicited from the learners. He used nine Thematic items that were connected through four semantic relations viz, Item/Elaboration, Attribute/Carrier, Process/Target, Qualifier/Thing, where Item/Elaboration was the most predominant semantic relation constructed. The sequences above started with the construction of a quantifier thing semantic relation where the teacher asked his learners to identify one characteristic that they wanted to deal with. Mr. Zulu started with this type of relation to focus his learners on the concept of a 'monohybrid cross' where they would deal with one characteristic only. On this note, it is important to note that Mr. Zulu omitted the use of the word trait as a synonym for the word characteristic. Thus, the semantic relation synonym/synonym was not evident in his Thematic pattern. This relation is important to the learners in the sense that some examiners use the two words characteristic and trait interchangeably, hence the learners are expected to know and use both. The Attribute/Carrier semantic relation was constructed to describe the term gene (turn 49), structure of a gene (63, 64, 65), heterozygous, homozygous (turns 76, 83) as well as dominant and recessive (turn 84). This type of relation was associated with the Item/Elaboration relation where the teacher clarified the meanings of the following terms: gene and allele (turns 46, 50, 52), homozygous (59), gene (63, 64) heterozygous (turn 74) homozygous, heterozygous, allele, dominant and recessive (turns 77-82). Like Mr. Zindi, Mr, Zulu constructed more Item/Elaboration semantic relations to clarify meanings and provide examples to enhance learners' understanding. The predominant construction of the item/Elaboration semantic relation suggests that Mr. Zulu like Mr. Zindi afforded his learners opportunities to construct Thematic patterns with their support as teachers.

5.5.3 Dealing with the concept of gene

Example 2

Curricular Development of Thematics: Teacher External Thematics

Mrs. Letsiba dealt with the concept of genes using an example elicited from one of the learners. She focused on the concept of 'gene' by constructing the Teacher External Thematics shown in the exchanges below by herself without learner participation. The learner known as Mario participates in the dialogue by assigning the external authority a participant role as he reads the course textbook. Whatever he said was not his contribution. Therefore, the Thematics below are referred to as Teacher External Text Thematics. The excerpt below was extracted from Mrs. Letsiba's episode 8 of Lesson Observation 2 where he was focusing on the concept of 'gene'.

Mrs. Letsiba LO2: the concept of gene

175.	Mrs. Letsiba:	Can you check again in our study guide…the **dominant** and the **recessive**…**dominant** and **recessive** so you understand— see it on page 31 you read that for me Mario…**dominan**t **gene**.
176.	Mario:	[Reading from study guide] '**Dominant gene**, a **gene** that expresses itself in the **phenotype** of an individual and masks the effect of the **recessive gene**'. *DEFINITION*
177.	Mrs. Letsiba:	So, you are having that black eyes from your mother!
178.		And then we have that…that **recessive**… *ITEM/ELABORATION*
179.		So, the **dominant** will musk what…THE **recessive** *ITEM/ELABORATION*
180.	Mrs. Letsiba:	We will not unless otherwise we are going to what…in our **second filial generation** some of these **offspring** here are going to be tall and some of the **offspring** are going to be what short. *ITEM/ELABORATION*
181.		That is our **second filial generation**. *CLASSIFIER/THING*
182.		Sit there my boy I will come to you [referring to a learner] …and then you read again [referring to Mario] **recessive.**
183.	Mario:	[Reading] 'A **gene** that does not express itself in the **phenotype.**' *DEFINITION*
184.	Mrs. Letsiba:	A **gene** that does not express itself on THE **pheno-type.** *DEFINITION*
185.		Remember the **phenotype** is what… ((the physical appearance)) [using hands and body]. *DEFINITION*
186.		As I was saying now that last week when you were here with your mom [referring to Mario]
187.		I did not ask questions by just merely looking at HER **PHENOTYPE** that is her physical appearance! *DEFINITION*
188.		BY the mere fact that you-- some of your features…the **phenotype**… they are the same. *ATTRIBUTE/CARRIER*
189.		but it does not mean that even if some of these features which are the same which are expressed in the **phenotype**, then that **recessive allele** we throw away. *ITEM/ELABORATION*

Mrs. Letsiba LO2, episode 8

The exchanges above started with Mrs. Letsiba listing terms (dominant, recessive, and dominant gene) and asking a learner Mario so that she could draw from the external authority (course textbook) to construct semantic relations which are similar to the ones prescribed by the textbook. This is one of the areas where teachers like Mrs. Letsiba who were assessment-focused differed from Mr. Zindi and Mr. Zulu who were focused on building concepts. the conceptual development-focused teachers drew on the textbook for questions for consolidation during the revision of either classwork or homework. The excerpt below shows Mr. Zindi's views about consolidation.

263.	*R:*	*Ehm. In the last lesson that I observed, you distributed a worksheet for homework.*
264.		*What is the significance of homework in your teaching?*
265.	*Mr Zindi:*	*Yes…to me homework is consolidation.*
266.		*You have taught, you have discussed, and you think learners have understood.*
267.		*Some may have understood, some may have understood but there could be some who do not even know what they do not know.*
268.	*R:*	*Ehm.*
269.	*Mr Zindi:*	*You understand my point?*
270.	*R:*	*Ehm.*
271.	*Mr Zindi:*	*Right! Some learners sit there, you teach them they walk out but they do not know what they actually do not know, or they do not know.*
272.		*So, you should give them homework, you are now consolidating.*
273.		*They are going to do the homework and they are going to realise that they do not know this part of the concepts.*
274.		*So, that can be a way for the learner to come back tomorrow and ask for clarification.*

Mr. Zindi INT

The excerpt above shows that Mr. Zindi strongly expressed the view about consolidation through homework and the role it plays in his learners to go through a conceptual understanding of what was taught during the lesson. The excerpt above provides evidence that Mr. Zindi was interested in conceptual understanding in his learners.

Mrs. Letsiba used seven Thematic items (dominant, recessive, dominant gene, recessive gene, phenotype, second filial generation offspring, gene) to construct four semantic relations viz, Definition, Item/Elaboration, Classifier/Thing and Attribute/Carrier. It is also important to note that Mrs. constructed the Definition of semantic relation where the word gene was used to refer to allele. For instance, the *'dominant gene'*, and *'recessive gene'* (turn 176). It is clear from the excerpt that the misconception in Mrs. Letsiba's Thematic pattern above originated from the course textbook. When dealing with the concept of 'gene' Mrs. Letsiba's practice just like Mrs. Durand's was associated with more Definitions, perhaps this was caused by drawing on external authority which is her course textbook. This practice of depending heavily on the textbook or teacher notes is associated with assessment-focused teachers whose interest is to teach learners for passing rather than for conceptual understanding. Hence Mrs. Letsiba and Mrs. Durand taught curriculum development for learners to get marks in tests and exams.

5.5.4 Dealing with the concept of monohybrid cross

Example 1

Conceptual Development of Thematics: Joint External Thematics (JET)

Mr. Zulu dealt with the concept of genes using an example elicited from one of the learners. He focused on the concept of 'monohybrid cross' by constructing the Joint External Thematics shown in the exchanges below together with his learners while consulting external authority for a question to use during the construction of Thematic patterns. So, the teacher assigned the text a participant role as he read a question to the learners from his notes. Therefore, the Thematics below are referred to as Joint Text Thematics. The excerpt below was extracted from Mr. Zulu's episode 3 of Lesson Observation 2 where he was dealing with the concept of the 'monohybrid cross'. (N.B the transcription conventions used in this transcript and proceeding ones are presented in table 4.2 in Chapter 4)

Mr. Zulu LO2: The concept of gene

88.	Mr. Zulu:	Yes! Right, so let us say… [writing on the transparency] …brown and…brown okay and what do we call this?
89.	Mr. Zulu:	Is this the **genotype** or **phenotype**? *ITEM/ELABORATION*
90.	Ls:	[Hesitantly] **Genotype.** *ITEM/ELABORATION*
91.	Mr. Zulu:	Sorry…↓**Genotype!** *ITEM/ELABORATION*
92.	Ls:	**Phenotype.** *ITEM/ELABORATION*
93.	Mr. Zulu:	It is the **phenotype**, why is it **the phenotype**? Yes? [Referring to a learner] *ITEM/ELABORATION*
94.	Lesedi:	We can see it. *ITEM/ELABORATION*
95.	Mr. Zulu:	Yes, we can see that characteristic, it is the physical appearance of an organism. *ITEM/ELABORATION*
96.		If we look at these two people [pointing to the letters on the transparency], we will see the brown eyes!
97.		So, we will say this is the **phenotype**, I will not write it in full because we do not have enough space here [fixing the projector] okay. *ATTRIBUTE/CARRIER*
98.		So, this will be the **phenotype** and then now let us represent the **genotype** okay. *ATTRIBUTE/CARRIER*
99.		So, will just put a G for **genotype**, so the **genotype** for this one, let us say this first [pointing to the letters on the transparency] parent is **homozygous** for brown eyes and remember we said we are going to use the letter B. *ATTRIBUTE/CARRIER*
100.		If this parent is **homozygous** for brown eyes so which letters—how are we going to put our letters? Yes? [Referring to a learner] *ITEM/ELABORATION*
101.	Lesedi:	Capital letters!
102.	Mr. Zulu:	[Writing on the transparency] Capital B and ((Capital B)).
103.		Yes! Remember we use two **alleles** … for each parent because this parent inherited this [pointing to one B] from… *ITEM/ELABORATION*
104.	Lesedi:	Mother
105.	Mr. Zulu:	Yes! [pointing to a letter on the transparency] From the mother and from their father as well. [Pointing]
106.		So, for this one… [pointing to the word brown on the transparency] …it is said to be **heterozygous**, **heterozygous** how are we going to represent the **alleles**? Yes, Alumba? *ITEM ELABORATION*
107.	Alumba:	Capital B and a small b.
108.	Mr. Zulu:	It is capital B and a small letter b.
109. is		Okay, between the two which one is **dominant** here and which one **recessive**? Yes? [Pointing to a learner] *ITEM/ELABORATION*
110.	Alumba:	The capital B is **dominant.** *ITEM/ELABORATION*
111. this	Mr. Zulu:	[Referring to letters on the transparency] This one is **dominant** and one is **recessive**.

112.		Let us check this one… [pointing to the transparency]…okay which one is **dominant**, and which one is **recessive**? *ITEM/ELABORATION*
113.	Ls:	They are both…
114.	Mr. Zulu:	They are both **dominant** okay, they are both **dominant**.
115.		^Now, we should start with our **crossing**. *ITEM/ELABORATION*
116.		Boys you are-- you still remember **sexual reproduction**…we said in **sexual reproduction**… the two **gametes** will come together. *ITEM/ELABORATION*
117.		It will be **sperm** from the father and an **egg** from the mother. *ITEM/ELABORATION*
118.		Right, so it means that even here we must represent that... we must show the process **meiosis**. *PROCESS/TARGET*
119.		We have to say that **meiosis** is taking place…okay **meiosis** is taking place. *MEIOSIS/TARGET*
120.		After **meiosis** what are we going to have…we will have…
121.	Alumba:	**Mitosis!**
122.	Mr. Zulu:	^Ahh… NO! No!
123.		Not **mitosis**.
124.		What is going to be formed?
125.	Ls:	**Four cells**! *PROCESS/TARGET*
126.	Mr. Zulu:	Okay, it is fine but then at the end those **four cells** will what— form THE **GAMETES**! *PROCESS/TARGET*
127.		Right, so what… are we going to have as our **gametes** here any idea? Yes? [Referring to a learner] *ITEM/ELABORATION*
128.	Mpho:	Eye colour sir. [Pointing to the transparency]
129.	Mr. Zulu:	[Smiling] Okay so because we are looking are at the eye colour only… so, it means even our **gametes**…will be representing our eye colour and the **gametes**…boys they are the same as the **genotype.** *CARRIER/ATTRIBUTE*
130.		The only difference…now is that you will BE using a circle.
131.		Right, so we have this B and we have another B and we put this B in a circle ^we also put this one in a circle, because they have to come together that is why we use this sign which is like a multiplication sign.
132.		Then we have this one which will be capital letter B and a ^small letter right, and we put them in a circle and the reason for that… it is because these are **gametes** these are **gametes**, am I making sense? *ITEM/ELABORATION*
133.		It is the **gametes** that will come together to form an **offspring**. *PROCESS/TARGET*
134.		Remember we want to see how the child is going to be in this case, right we want to see how the child is going to be.
135.		So, it is the gametes that will come together, it is not just these **genotypes** and the **phenotype.** *ITEM/ELABORATION*
136.		You cannot put two parents together and expect a child to come out.
137.		There must be **copulation** and during **copulation** a **sperm** will be released and then an **egg** will meet and then we have a process of **fertilization.** *PROCESS/TARGET*
138.		So, by just two parents standing next to each other it does not mean that they will have an **offspring**. *ITEM/ELABORATION*
139.		There must be **copulation**, there must be sperm that will **fertilize** an **egg**. *PROCESS/TARGET*
140.		So, that is why we must represent these **gametes**… [pointing to the transparency] alright. *ITEM/ELABORATION*
141.		So, in this case now we have **gamete**s… [writing on the transparency] after the process of **meiosis** are we following? *ITEM/ELABORATION*
142.	Ls:	Yes!

143.	Mr. Zulu:	Okay, right so because we know that **fertilization** is random *PROCESS/TARGET*
		it can be any **sperm** that fertilize an **egg.** *PROCESS/TARGET*
144.		It will also be brown okay.
145.		Then [pointing to the transparency] what about this one?
146.	Ls:	Brown.
147.	Mr. Zulu:	It will also BE…
148.	Ls:	Brown.
149.	Mr. Zulu:	…because we say this one will mask the effects of this.
150.		Right, so all of them will have brown eyes.
151.		Now the question in the exam says, "what is the **phenotypic ratio** of the F_1 when two individuals who are **homozygous** and **heterozygous** for brown eye colour"? Yes, Lindani! *QUANTIFIER/THING*

Mr. Zulu LO2, episode 3

The excerpt above shows that Mr Zulu used seventeen thematic items (refer to Appendix F3 for all items) to construct four semantic relations viz, Item/Elaboration, Attribute/Carrier, Process/Target, Quantifier/Thing. The most predominant semantic relations constructed in Mr Zulu's classroom when dealing with the monohybrid cross was Item/Elaboration where the teacher clarified meanings of words like phenotype (turn 95), homozygous (turn 99), alleles and symbols (turn 106), dominant and recessive and symbols (turns 109, 110). The Item/Elaboration semantic relation was connected to other semantic relations such as Process/Target, where it was used to clarify processes such as fertilization and meiosis. Mr. Zulu's practice stood out in this case in the sense that he connected the concept of genetic cross back to reproduction and connected fertilization to copulation. This connection of semantic relations (Thematic pattern) is important for building a conceptual understanding of the science conceptual systems (Axelsson & Jakobson, 2020). As a conceptual development-focused teacher, Mr. Zulu drew on external authority for questions to assist him in teaching his learners inductively from example to rule as shown in the excerpt (turn 150) where he constructed the Quantifier/Thing relation to find out the phenotypic ratio. The teacher in this case was using the external authority as a tool for building conceptual understanding in his learners. Thus, Mr. Zulu afforded his learners opportunities to build a conceptual understanding of the genetics terms[5]. Building semantic relations (Thematic patterns) together with learners is good for the learners because it allows teachers to offer their learners support for 'talking science' (Lin & Lo, 2017).

[5] Phenotype, genotype, allele, homozygous, heterozygous, dominant, recessive, sexual reproduction, gametes, sperm, egg, meiosis, cells, copulation, fertilization, phenotypic ratio, offspring

Example 2

Procedural Development of Thematics: Joint External Thematics (JET)

Mrs. Letsiba dealt with the concept of genes using an example elicited from one of the learners. He focused on the concept of 'monohybrid cross' by constructing the Joint External Thematics shown in the exchanges below together with his learners while consulting external authority for a question to use during the construction of Thematic patterns. So, the teacher assigned the text a participant role as he read a question to the learners from his notes. Therefore, the Thematics below are referred to as Joint Text Thematics. The excerpt below was extracted from Mr. Zulu's episode 3 of Lesson Observation 2 where he was dealing with the concept of a 'monohybrid cross'.

Mrs. Letsiba LO2: The concept of monohybrid cross

99.	Mrs. Letsiba	So, as **Gregor Mendel** here [showing it on the board] with this **plant** here the tall and the **short plant**. *PROCESS/TARGET*
100.		The **homo—zygous tall** and also the **homo—zygous short** [still showing on the board]. *ATTRIBUTE/CARRIER*
101.		So, he started to do what to do his **crossing**. *PROCESS/TARGET*
102.		So, we have what people…we have [consulting the study guide] the first thing that we need to write there because normally this it can be around [writing a '6' on the board] six to seven marks.
103.		I always tell you that you must find out where the six marks are coming from.
104.		They are not just going to give you marks because you have written tt times tt.
105.		Then they are giving you six-- the way I forever show you diagrams…
106.		Whenever you are plotting a **graph**-- if the **graph** is saying seven marks you need to know then that-- where these marks are coming from… where are you going to lose marks… [using hands] *ITEM/ELABORATION*
107.		Your plotting, your scale, your labelling, your caption, that must involve what… the two **VARIABLES** you understand! *PROCESS/TARGET*
108.		So, we have what here…we have…THE [writing on the board] the **PHENOTYPE** *ITEM/ELABORATION*
109.		So, what is our **phenotype** here? [Showing on the board] *ITEM/ELABORATION*
110.		It is tall a:nd ((short)) because we are able to do what… [using hands] to describe our two **plants** that the other one is tall… and the other one is ((short)). *ATTRIBUTE/CARRIER*
111.		And then from- it will be what… the [writing on the board] …**geno-((type)).**
112.		What is our **genotype** here? *ITEM/ELABORATION*
113.		That is when you are writing what…your TT and the small letter t…T capital letter **HOMO— zygous tall** and a short plant that is the **homo— zygous** short. [Pointing to a learner] *ITEM/ ELABORATION*
123.		So, and ↓we are referring to this one here [showing on the board]
124	Ls:	Yes!
125.	Mrs. Letsiba:	…the **genotype** TT and tt. *ITEM/ELABORATION*
126.		And then from there, we have what **meiosis.**
127.		There must be **meiosis** and then **gametes** and then **ferti—((lization)).** *PROCESS/TARGET*

128.		Then you will get another mark here, [showing that on the board] just for you to do what…to write that **meiosis**, **gametes** must follow that order you do not have to start with **fertilization,** no!
129.		You do not have to start with that **gametes**…we know it has tobe **meiosis**…sorry it is **gametes** and then **fertilization**. [Writing on the board] *PROCESS/TARGET*
130.		So, what will be here?
131.		And then we have again our tt then you start to do what… [writing on the board] to do your cross, you do your **cross,** and then you do your **cross**, then you do your **cross** then look at our results here… [goes to the other side of the board] *PROCESS/TARGET*
132.		We are having what [circling the letters] the capital letter T first **offspring** that is the capital letter T and then this one here again the capital letter T, the third one again we have what, the capital letter T …and the last one you also have what the capital letter T.
133.		So, which means that these **offspring** here [showing on the board] they are ALL TALL because of what…because of this capital letter T. *PROCESS/TARGET*
134.		And we are no longer…referring to them as what…as **HOMO— ((ZYGOUS))** but then they are what… **((HETERO— ZYGOUS))** *ATTRIBUTE/CARRIER*

Mrs. Letsiba LO2, episodes 6 and 7

Lines 114-124 were skipped since they had nothing to do with the concept in question.

As an assessment-focused teacher Mrs. Letsiba started by constructing a Process/Target relation because she wanted to use Mendel's work for the Monohybrid cross and consulted her course textbook as she referred to the mark allocation in examination questions (turns 99-103). Her strong interest in drilling her learners for passing examinations caused her to digress from the objective of the lesson and start talking about graphs and their mark allocations (turns 160, 107). Concerning examinations Mrs. Letsiba had this to say.

289.	*R:*	*Yah your teaching is ahh--when you are doing your teaching, you link it a lot to examinations.*
290.		*Why the emphasis on examinations?*
291.	*Mrs Letsiba:*	*[Silence] There-- yah… I am not going to set the examination.*
292.	*R:*	*Yah.*
293.	*Mrs Letsiba:*	*Someone, somewhere…*
294.	*R:*	*Ehm.*
295.	*Mrs Letsiba:*	*… is going… is setting the examination.*
296.	*R:*	*Ehm.*
297.	*Mrs Letsiba:*	*We have to be ready.*
298.	*R:*	*Ehm.*
299.	*Mrs Letsiba:*	*So that is why… even with my marking for example…[clearing throat] the of the… SBA … I always tell them that… I cannot just put… ticks there that… it is six marks.*
300.		*You have to understand… where that six marks are coming from.*
301.	*R:*	*Ehm… Ehm.*
302.	*Mrs Letsiba:*	*You understand!*
303.	*R:*	*Yes!*
304.	*Mrs. Letsiba:*	*And then which areas… you know that… because some of the marks I am actually calling… I am referring them as the free marks.*
305.	*R:*	*Ehm.*

306.	*Mrs Letsiba:*	*That… you write whatever they get in the caption… is what… it is a free mark.*
307.	*R:*	*Ehm.*
308.	*Mrs Letsiba:*	*The labelling of your axis, it is a free mark*
309.	*R:*	*Ehm.*
310.	*Mrs Letsiba:*	*So, before you can even start plotting that graph… because it is the way they are going to mark at the end of the year.*
311.		*So, my emphasis whenever I am teaching ma'am…*
312.	*R:*	*Ehm.*
313.	*Mrs Letsiba:*	*…whenever I am teaching, I say okay… you write NB next to this here…*
314.	*R:*	*Ehm.*
315.	*Mrs Letsiba:*	*… because it is what you will get in the examination.*

Mrs. Letsiba INT

The excerpt above shows that Mrs. Letsiba strongly expressed the view about his interest in examinations and how she wants her learners to know the mark allocations to pass their examinations. The excerpt above provides evidence that Mrs. Letsiba was assessment-focused.

The construction of more Process/Target during these two episodes provides convincing evidence that Mrs Letsiba was interested in her learners getting the process of doing a genetic cross right rather than understanding and linking it with the other concepts such as reproduction and meiosis in detail. Mrs. Letsiba constructed very few Item/Elaboration semantic relations which suggests that meanings of words were not clarified. This also provides further evidence that Mrs. Letsiba like Mrs. Durand was focused on developing the curriculum so that learners get marks. So, they focused on the Examination Guidelines to the letter. In the next section, I present summary of my findings.

5.6 Summary of key findings relative to development of genetics concepts during the teaching of basic genetics

Reverting to the research question: ***How do teachers develop genetics concepts during the teaching of basic genetics to grade 12 learners?***

5.6.1 Emerging types of teachers

The four teachers' Locus of Thematic development 'maps' and profiles revealed two types of teachers viz, the one who is conceptually focused, and the other one who is assessment focused. On the one hand, Mrs Durand's, and Mrs. Letsiba's Locus of Thematic Development 'maps' portrayed them as assessment-focused where their interest was in learners getting marks rather than understanding the concepts. Their maps show that the majority of the Thematics constructed in their classrooms were Teacher Thematics **(TT)**. Both teachers focused on covering the curriculum for examination purposes and constructed semantic relations (Thematic patterns) on their own without learner participation. There was no evidence of meaningful consolidation in both classrooms instead the construction of Thematic patterns was associated with the teachers asking simple questions. Hence, these simple questions lead to the construction of a few Joint Thematics **(JT)** which were characterised by learners completing statements or clauses started by the teacher. In some cases, Mrs. Durand and Mrs. Letsiba constructed Teacher Thematics coupled with External Text Thematics **(TET)** they drew on external authority to construct the Thematic patterns. In this case, they consulted their notebook or textbooks for the definitions of terms. Overall, Mrs. Durand's and Mrs. Letsiba's practice was associated with the construction of more Teacher Thematics **(TT),** fewer Joint Thematics **(JT)** and Teacher Thematics coupled with External text Thematics). Thus, this analysis uncovered the following.

MORE TT + FEWER JT + TET = ASSESSMENT FOCUSED TEACHER

To develop the curriculum both Mrs. Letsiba and Mrs Durand constructed more Definition-semantic relations most of which were constructed directly from the teacher's notes or course textbook. They also constructed Item/Elaboration relations, Attribute/Carrier and Process/Target which seemed to be disjointed. This is because there were few cases where terms were elaborated by clarifying and providing examples. These teachers used the Item/Elaboration to clarify the meanings of terms and to provide examples to assist their learners in going through conceptual understanding. Furthermore, in terms of Thematic items, both Mrs. Letsiba and Mrs. Durand used fewer Thematics items and some of them were not relevant to the taught concepts.

On the other hand, Mr. Zindi's and Mr. Zulu's Locus of Thematic Development 'maps' portrayed them as conceptually focused where their interest was on developing an understanding of the concepts in their learners. Their maps show that the majority of the Thematics constructed in their classrooms were Joint Thematics **(JT)**. Both teachers focused on understanding concepts and co-constructed semantic relations (Thematic patterns) during the development of concepts together with their learners. There was evidence of meaningful development of concepts in both classrooms where the construction of semantic relations (Thematic patterns) was associated with the teachers asking learners higher-order questions requiring reasoning, clarification, or justification. Hence, these higher-order questions led to the construction of a more Joint Thematics **(JT)** Mr. Zindi and Mr. Zulu constructed Joint

Thematics coupled with External Text Thematics **(JET)** as they drew on external authority to construct the Thematic patterns. In this case, they consulted the course textbook or past examination questions. There was evidence of meaningful consolidation in Mr. Zindi and Mr. Zulu's classrooms where they consolidated and expressed the logic of the discussed content through the construction of Teacher Thematics **(TT).** These are instances of a few cases where these two teachers constructed Teacher Thematics. Overall, Mr. Zindi's and Mr. Zulu's practices were associated with the construction of more Joint Thematics **(JT),** fewer Teacher Thematics **(TT)** and Joint Thematics coupled with External text Thematics). Thus, this analysis uncovered the following.

MORE JT + FEWER TT + JET = CONCEPTUALLY FOCUSED TEACHER

To develop the concepts both Mr. Zindi and Mr. Zulu constructed more Item/Elaboration semantic relations most of which were co-constructed by the teachers together with their learners. In addition, they constructed other types of semantic relations viz, Attribute/Carrier and Process/Target which seemed to be connected to the Item/Elaboration relation. The Item/Elaboration relation was used for clarifying and providing examples of newly introduced concepts to assist their learners in going through conceptual understanding.

5.7 Chapter Summary

In this chapter, I presented findings based on my first sub-research question presented above in terms of the three categories viz, Locus of development of Thematics, Thematic items, and semantic relations which give us the thematic pattern when combined. The Locus of Thematic Development 'maps', teacher Locus of Thematic Development Profiles and Thematic patterns constructed unveiled two kinds of teachers viz, conceptual development focused teacher and assessment focused teacher. In the next chapter, I will present the discussion of my findings based on my second sub-research question which reads, *what kinds of emergent teacher strategies can be extracted from the Discourse of teaching basic genetics to grade 12 learners?*

CHAPTER 6: CLASSROOM INTERACTION PATTERNS AND TEACHER DISCOURSE MOVES

6.0 Introduction

In Chapter 5, I dealt with Thematics as I addressed my first research question which centred on how teachers developed genetics concepts during the teaching of basic genetics to grade 12 learners. I did this by focusing on the following aspects: locus of thematic development, thematic items, semantic relations, and thematic patterns.

In this chapter, I present results and major findings for the four participant teachers in terms of the second sub-research question highlighted below:

What forms of interaction patterns and teacher Discourse moves are evident during the teaching of basic genetics to grade 12 learners?

To answer this research question, analysis of the teachers' Discourse explored interaction patterns evident during the teaching of basic genetics to grade 12 learners in terms of the following three aspects presented in the theoretical framework (Figure 2.3) developed in Chapter 2.

- Communicative approach
- Patterns of Discourse
- Teacher Discourse moves

Literature highlights that some interaction patterns can be helpful in developing learners' shared understanding of science concepts and reasoning ability (Kimmerle et al., 2015; Rocksén, 2015). Thus, in an attempt to identify the kind of Discourse that contributed to the learning of genetics concepts (productive Discourse) like Iqbal and Mahmood (2020), I was influenced by the social constructivist perspective. The social constructivist perspective draws upon the idea that knowledge and meanings are actively and jointly constructed by individuals (Amineh & Asl, 2015). In this study, the teachers' Discourse was considered to be productive Discourse when it displayed some of the characteristics presented in Figure 6.1.

Types of communicative approaches
Dialogic interactions *-explore of learners' ideas and perspectives* *-allow meaningful/deep learner participation* *- support knowledge building by linking the scientific view to everyday views* *-trigger and support learner interest*
Types of Discourse patterns
Extended chain patterns *-maximise learning by supporting and evoking creative thinking* *-provide scope for greater interactivity and analysis of varying ideas*
Types of Teacher Discourse moves
Building moves (reasoning and clarification) *-have the potential to support learner conceptual reasoning* *-non-evaluative moves* *-push learners' thinking further* Connection move -*Support knowledge building by linking the scientific view to everyday views* *-support link-making* *-enhances understanding of new concepts*

Figure 6. 1: What constitutes productive Discourse?

(Ellis et al., 2019; Howe et al., 2019; Juuti et al., 2020; Lim et al., 2020; Rubic, 2017; Scott & Ametller, 2007; Scott et al., 2011)

6.1 Data sources for this chapter

In this study, the main sources of data were the twelve lesson observation transcriptions which were generated from video recordings of a series of three consecutive lessons taught by four teachers to grade 12 learners during the teaching of basic genetics. As mentioned previously, detailed transcriptions of lesson observations were used to capture gestures, physical movements of teachers and learners, board work, and practical demonstrations. To augment the video data, other sources of data viz, post-lesson observation interviews and field notes were used for data triangulation purposes. This helped me to access teachers' rationale for taking certain actions during the observed lessons. Moreover, the interviews provided more information for answering the sub-research questions and enhanced the trustworthiness of my analysis as the various data collection methods complemented each other.

6.2 Method of Analysis

To analyse data for this chapter, as mentioned earlier, I started by identifying the episodes that consisted of an utterance or utterances that indicated the presence of a statement of genetics and/or question about genetics concepts in each of the teachers' lesson observation transcripts which I refer to as 'Discourse Episodes' in this study. My analysis for this chapter was influenced by studies conducted by Lemke (1990) and Scott and Ametller (2007) on communicative approaches and patterns of Discourse as well as Carpenter et al. (2020) on Teacher Discourse moves. These are shown in the second categories respectively (interaction patterns and Discourse moves) of the coding system presented in Table 4.3 in Chapter 4.

After identifying all the Discourse Episodes for all the teachers, I identified the communicative approaches (Scott & Ametller, 2007) engaged by the teachers. These included interactive/dialogic, non-interactive/dialogic, interactive/authoritative, and non-interactive/authoritative (discussed in detail in section 4.6.1). In cases, where teachers engaged in the interactive/dialogic communicative approach, they explored ideas with their learners, asking questions, as they offered, listened, and worked on different points of view (Scott & Ametller, 2007). In terms of a non-interactive/dialogic communicative approach, though the teachers considered different points of view and worked on various perspectives, they excluded participation from their learners (Scott & Ametller, 2007). With an interactive/authoritative communicative approach, the teachers led their learners through sequences of questions and answers channelled toward one specific point of view. In this case, the learners' contributions were limited to single statements made as they responded to their teachers' questions. In terms of the non-interactive/authoritative approach, the teachers presented a specific point of view while excluding learners' participation.

Identification of patterns of Discourse followed (discussed in section 4.6.1) which included I-R-E/F (question–response–evaluation/Feedback) as described by Howe and Abedin (2013) which is characterised by the teacher's evaluation or elaboration of learners' response. Rather than evaluating or elaborating on a learner's response, the teacher may prompt a learner for further elaboration of his/her point of view thus sustaining the interaction. According to Scott et al. (2006), this usually produces interaction chains that follow an I-R-P-R-P-R- or I-R-P-R-P-R-E where pattern, P stands for prompt. The prompt by the teacher (seeking elaboration) is followed by a further response from the learner represented by R and the chain continues. This interaction chain can be open with no final evaluation (I-R-P-R-P-R-) or closed by a final evaluation from the teacher (I-R-P-R-P-R-E). In cases where there was teacher talk only the Discourse pattern in this study, was referred to as the telling.

Lastly, I performed an analysis of teacher Discourse moves to determine how teachers worked with learners' ideas. In this study, I define teacher Discourse moves as actions that teachers can plan carefully and use to open up the classroom Discourse. During analysis, I regarded teacher Discourse moves as specific turns of teacher talk that were used to promote learner talk and achieve certain instructional goals (Windschitl et al., 2020). Consequently, I drew from literature (Carpenter et al., 2020; Ellis et al., 2019; Khoza, 2023) and constructed a list of provisional codes to capture diverse teacher Discourse moves. As I engaged in the coding process, I iteratively improved the codes and added more that were unveiled from the data (Saldaña, 2021). I then classified the final codes (Carpenter et al., 2020) into five groups of moves: eliciting, marking, building, evaluation and others. My final set of twelve codes and five groups is shown in Table 6.1.

Table 6. 1: Teacher Discourse moves

Categories of teacher Discourse moves	Teacher Discourse moves	Description
Eliciting moves	Eliciting learner ideas/Probing or explaining Eliciting ideas	Questions that invite students to elaborate on particular ideas
	Eliciting connections Connections	Eliciting/making connections to learners' own experiences Having learners connect prior knowledge to current learning to display their new understanding
	Determining a range of learner responses/Eliciting further responses Determining range	The teacher gauges a range of learner ideas by eliciting responses from several learners or groups of students, or by asking for different kinds of responses
Marking moves	Repeating learner response Repeating	The teacher repeats part or all of what the learner stated
	Revoicing, teacher elaboration Revoicing	The teacher uses scientific terms or concepts to restate rephrase or elaborate on learner responses
	Agree/disagree Agree/ disagree	The teacher asks learners if they agree or disagree with other learners' responses

Categories of teacher Discourse moves	Teacher Discourse moves	Description
Building moves	Eliciting learner reasoning or Justify Reasoning	The teacher asks learners to explain their reasoning.
	Asking for clarification/example Clarification	The teacher follows up the response by asking students to clarify what they said or to provide a representative example
Evaluation moves	Motivating	Encouragement of learner participation in revealing their understanding Celebrating learner's work through praise or encouragement
Selecting moves	Selecting	Selecting learners' work for discussion
	Put-downs	Remarks intended to criticize
Other moves	Providing information	Teachers introduce new ideas, facts, procedures, strategies, or conceptual explanations/conceived as a form of telling

Adapted from Carpenter et al. (2020); Ellis et al. (2019); Khoza (2023)

In the next section, I present the distribution of teacher communicative approaches, patterns of Discourse and Discourse moves in the four teachers' lessons as they taught genetics concepts to grade 12 learners.

6.3 Distribution of teacher communicative approaches, patterns of Discourse and Discourse moves in the four teachers' lessons

Table 6.2 shows the communicative approaches, patterns of Discourse (Scott & Ametller, 2007) and Teacher Discourse moves (Carpenter et al., 2020) that were evident in the twelve lessons observed when the teachers were dealing with the listed genetics concepts. Of the four communicative approaches, the noninteractive/authoritative (NIA) was common in all lessons while the interactive/authoritative (IA) was identified in eleven lessons. However, despite being regarded as the most productive Discourse (Figure 6.1), dialogic Discourse was scarce in this study with a few combinations of the dialogic Discourse identified in some of Mrs. Letsiba and Mr. Zulu's lessons. On the one hand, when dealing with the genetics concepts[6],

[6] abnormal meiosis and non-disjunction, meiosis, reproduction, inheritance, complete dominance, Mendel's crossing, genetic cross monohybrid, dihybrid crosses, blood groups, paternity testing, sex determination mutations, sex-linked disease, Down's syndrome, haemophilia, colour blindness, pedigree diagrams

Mrs. Letsiba recorded one interactive/dialogic and two noninteractive/dialogic instances in her three different lessons. On the other hand, when focusing on the genetic concepts[7], Mr. Zulu recorded two instances of interactive/dialogic and one instance of noninteractive/dialogic communicative approach in a single lesson.

Table 6.2 further shows that all twelve classes were associated with the telling type of Discourse where the teachers introduced and summarised genetic concepts through the providing information move. However, the teachers predominantly engaged in I-R-P-R-P/E interactions when dealing with the genetics concepts listed in the table with some instances of I-R-E/F being recorded. When engaging in I-R-E/F extended chain interactions, all teachers used the eliciting, teacher elaboration, repetition, and revoicing moves. All teachers except Mrs. Letsiba used the evaluative move on its own or together with the elaborative move. The selection move was only evident in Mrs. Letsiba's and Mr. Zulu's Classrooms. Lastly, the reasoning move was used in Mr. Zulu's and Mr. Zindi's classroom during lessons. Since the reasoning move is known for its potential to offer support for conceptual reasoning (Carpenter et al., 2020), this finding suggests that Mr. Zulu and Mr Zind offered their learners support for conceptual reasoning.

[7]phenotype and genotype, monohybrid crosses, genetic crosses, punnet square

Table 6. 2: Summary of distribution of teacher communicative approach, patterns of Discourse and Discourse moves

Teacher	Lesson	Genetics concepts	Communicative approach	Patterns of Discourse	Teacher Discourse moves
Mrs. Durand	1	Mitosis, meiosis, interphase, prophase, metaphase, early telophase, late telophase	NIA (14) IA (3)	Telling, I-R-E/F (common) I-R-P-R-P-R-P-R-P (1)	Providing information Eliciting, teacher elaboration, revoicing, connections
	2	Mendel's life history, Mendel's work, genetic crosses, problems	NIA (8) IA (4)	Telling, I-R-F (common) I-R (Learner question)	Providing information Eliciting, teacher elaboration, evaluation
	3	Mendel's life and work, genetic crosses monohybrid cross of pure breeds	NIA (8) IA (4)	Telling, I-R-F (common) I-R-P-R-P-R (Learner Question) I-R-P-R-P (Teacher Question)	Providing information, Eliciting, teacher elaboration
Mrs. Letsiba	1	Meiosis, abnormal meiosis and non-disjunction, Down's syndrome	NIA (4) IA (8) ID (1)	Telling, I-R-E/F I-R_1-R_2-R_3-R_4-F I-R-P-R-P-R-P (open chains)	Providing information, eliciting, teacher elaboration, elaboration, revoicing, determining range, selecting
	2	Meiosis, reproduction, inheritance, complete dominance, Mendel's crossing, genetic cross	NIA (6) IA (2) NID (1)	Telling I-P-R-P-R-F (learner initiation)	Providing information, Connections
	3	Monohybrid, dihybrid crosses, blood groups, paternity testing, sex determination mutations, sex-linked disease, Down's syndrome, haemophilia, colour blindness, genetic cross, pedigree diagrams	NIA (6) NID (1)	Telling	Providing information Connections

Teacher	Lesson	Genetics concepts	Communicative approach	Patterns of Discourse	Teacher Discourse moves
Mr. Zindi	1	Mitosis	NIA (8) IA (13)	Telling, I-R-E/F, I-R-F, I-R-P-R-E (closed chains), I-R-P-R-P-R-P (open chains)	Providing information, eliciting, teacher elaboration, repetition, evaluation, revoicing
	2	Mendel's work and conclusions, genetic cross	NIA (12) IA (11),	Telling, I-R-E/F, I-R_1-R_2-F, I-R-P-R-P-R-P (long open chain)	Eliciting, determining range, elaboration, evaluation, repetition, connections, revoicing, selecting
	3	Genetic crosses, punnet square	NIA (11) IA (8)	Telling, I-R-E/F, I-R-P-R-P-R-P (long open chain)	Providing information, eliciting, evaluation, repetition, agree/disagree
Mr. Zulu	1	Mitosis, interphase, prophase, metaphase	NIA (4) IA (6)	Telling, I-R/F, I-R-P-R-P-R-P (long open chains)	Providing information, evaluation, repetition, elaboration, revoicing
	2	Phenotype and genotype, monohybrid crosses, genetic cross, punnet square	NIA (9) IA (13) ID (2) NID (1)	Telling, I-R-E/F I-R-P-R-P-R-P (l open chains) I-R-P-R-P-R-E (long closed chains)	Providing information, eliciting, revoicing, agree/disagree, repetition, evaluation (put-down), reasoning, teacher elaboration, connections, revoicing
	3	Dihybrid cross, genetics lineages, albinism with genotype, albinism with no genotype	NIA (20) IA (27)	Telling, I-R-E/F, I-R-P-R-P-R (open chain), I-R-P-R-P-R-E (closed chain	Providing information, eliciting, revoicing, repetition, teacher elaboration, evaluation, reasoning

Numbers in brackets- Instances, NIA- Noninteractive/authoritative, IA- Interactive/authoritative, ID- Interactive /dialogic, NID-Noninteractive/dialogic

In the next section, I present the communicative approaches that were evident in the four teachers' classrooms.

6.4 Communicative Approaches

According to Scott and Ametller (2007), the communicative approach deals specifically with questions like, whether or not the teachers interact with their learners by either taking turns in the Discourse or solely presenting the content. It also focuses on whether the teachers take the learners' ideas into account or not during their teaching. Four essential categories of communicative approach were identified viz, dialogic/interactive, dialogic/non-interactive, authoritative/interactive, and interactive/non-interactive. These are presented in Figure 2.2 in Chapter 2.

Generally, dialogic Discourse is open to different perspectives and participants usually strive to accept other peoples' views (Scott & Ametller, 2007). Thus, on the one hand, through dialogic Discourse, teachers consider their learners' viewpoints, interests and concerns (Calcagni & Lago, 2018) as they attend to the school science view. On the other hand, Scott and Ametller (2007) argue that authoritative Discourse does not allow linking up and consideration of different ideas. In this case, the teachers focus their attention on the school science point of view, while they reshape or ignore any ideas or questions not relating to the development of the scientific story at hand. Though authoritative Discourse is usually closed to other points of view and lacks exploration, more than one voice can be heard as learners are allowed to contribute to the discussion.

According to Scott and Ametller (2007) in terms of the four classes of communicative approach, the classroom talk is said to be interactive/dialogic when the teacher and learners focus on a range of ideas and ask each other genuine questions as they focus on different viewpoints. Classroom talk is considered to be noninteractive/dialogic when the teacher recaps or summarises different viewpoints by solely listing them or exploring the similarities and differences between the viewpoints. When teachers focus on one particular viewpoint and through a question-and-answer routine leading learners with the intention of establishing and developing that point of view, the classroom talk is said to be interactive/authoritative. Lastly, noninteractive/authoritative classroom talk is associated with the teacher presenting a specific viewpoint.

As can be seen from Figure. 16 the teachers in this study engaged all four types of communicative approaches viz, interactive/authoritative, interactive/dialogic, and non-interactive authoritative (Scott & Ametller, 2007). It further shows that the most common communicative approach adopted by all teachers was noninteractive/authoritative. This contradicts the findings obtained in the study by Kaya et al. (2016) who found the most preferred communicative approach to be interactive/authoritative. The second most common communicative approach was interactive/authoritative which was used in all except one (Mrs. Letsiba's LO3) of the observed lessons. The data also show that dialogic interactions were very rare in this study with only Mrs. Letsiba and Mr. Zulu engaging in very few instances. Lastly, there were few instances where teachers engaged in the non-interactive dialogic communicative approach in this study.

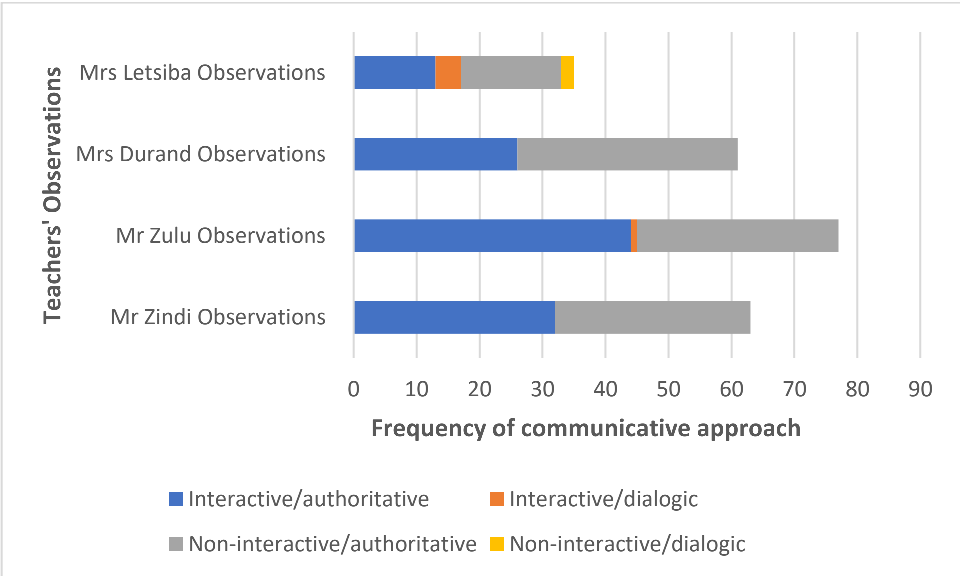


Figure 6. 2: Communicative approaches engaged in the series of three lessons per teacher

Figure 6.2 shows that on the one hand, Mrs Durand's, and Mr Zindi's lessons were characterised by authoritative Discourse which alternated from being non-interactive to interactive or vice versa. Interestingly these two teachers were from the same school. The dialogic part of Discourse was not evident in these two teachers' observed lessons. This provides evidence that Mrs Durand and Mr Zindi did not consider their learners' viewpoints as they attended the school science view (Scott & Ametller, 2007). On the other hand, Figure 6.2 shows that only Mrs. Letsiba and Mr. Zulu's lessons were dialogic at some point though their classrooms were dominated by the authoritative Discourse. This finding is consistent with Hiltunen et al. (2020); Juuti et al. (2020); Teo (2016) who found that dialogic approaches were rarely used by teachers. This implies that these two teachers focused their learners on other points of view as they developed the school science view (Scott & Ametller, 2007). It is also interesting to note that in this study, the non-interactive/dialogic communicative approach was only evident in Mr. Zulu and Letsiba's observations meaning that it is in these two classrooms only where the teachers exposed learners to other points of view during their talk.

Overall, based on the characteristics of productive Discourse presented in Figure 6.1, Mrs. Letsiba and Mr. Zulu's teaching can be regarded as productive teaching in the sense that they engaged their learners in dialogic approaches though they ultimately introduced the authoritative scientific view. This shift from the dialogic to authoritative is essential since meaningful learning entails making links between forms of thinking and talking so that the learners understand how new ideas match with pre-existing ideas (Scott & Ametller, 2007). Thus, these two teachers, through the dialogic approaches provided learners with opportunities to express their existing views and see how they relate to the science view.

It is interesting to note that despite not engaging in dialogic Discourse, Mr. Zindi understood its importance in supporting learners to understand the scientific view. This was evident in his interview session when he was asked a question about the importance of using real-life scenarios during teaching.

254.	*R:*	*Why are real-life scenarios important to you?*
255.	*Mr Zindi:*	*Ahh…you see when you are teaching, you are teaching in a classroom, but these learners have…they have their own life experiences outside the classroom.*
256.		*So, by relating to these scenarios, you are putting them in an environment in which they live.*
257.		*They live in the environment, they grow up and therefore, it makes it easy to understand the concepts because sometimes they think that what they learn is something…I mean which is out of this world. Real life scenarios*
258.	*R:*	*Ehm.*
259.	*Mr Zindi:*	*And yet what they learn is very, very much related to their day-to day lives.*
260.		*They live very close to what they learn in class. Real life scenarios*
261.	*R:*	*Ehm.*
262.	*Mr Zindi:*	*But sometimes they think that what they learn class has nothing to do with— or how we live.*

Mr. Zindi INT

The excerpt above shows that Mr Zindi strongly expressed the view that learners had their own experiences outside the classroom (turn 255) and that it is his role as a teacher to relate his learners' life experiences to the scientific concepts to be taught (turns 256, 257, 259,262). Based on Table 6.1 about what constitutes productive teaching, Mr. Zindi's view about learners' ideas provides evidence that he is aware of the importance of linking science and everyday views for knowledge building. Similar statements were made by Mrs Durand during her interview sessions which contradict what I observed in their practices. This concurs with previous research which highlighted that dialogic Discourse is hardly used (Howe & Abedin, 2013; Mavuru, 2019; Teo, 2016) though teachers are aware of how beneficial it is to science learning (Reznitskaya & Gregory, 2013; Scott et al., 2006). In the next section, I discuss the patterns of Discourse that were evident in this study.

6.5 Patterns of Discourse

In this study, triadic dialogue assumed two forms of Discourse pattern which are I-R-E-/F and I-R-F-P-R-P-R-/E. As discussed earlier in section 6.2, the I-R-E/F (Howe & Abedin, 2013) pattern was played out in a pattern of three, with utterances from teacher-learner-teacher where I-initiation, R-response and E-evaluation or E-feedback. The alternative form of triadic dialogue I-R-P-R-F-P-F-/E (Scott et al., 2006) is played out in patterns that form a chain of interactions. In this case, the teacher provides feedback by prompting instead of evaluating or elaborating on the learner's response. Hence, P stands for prompt from the teacher which can be followed by a further response from the learner/s.

6.5.1 Patterns of Discourse

Figure 6.3 shows that the patterns of Discourse that were evident in this study were I-R-E/F and I-R-P-R-P-R-P. Both patterns of discourse were evident in ten out of the twelve observed lessons.

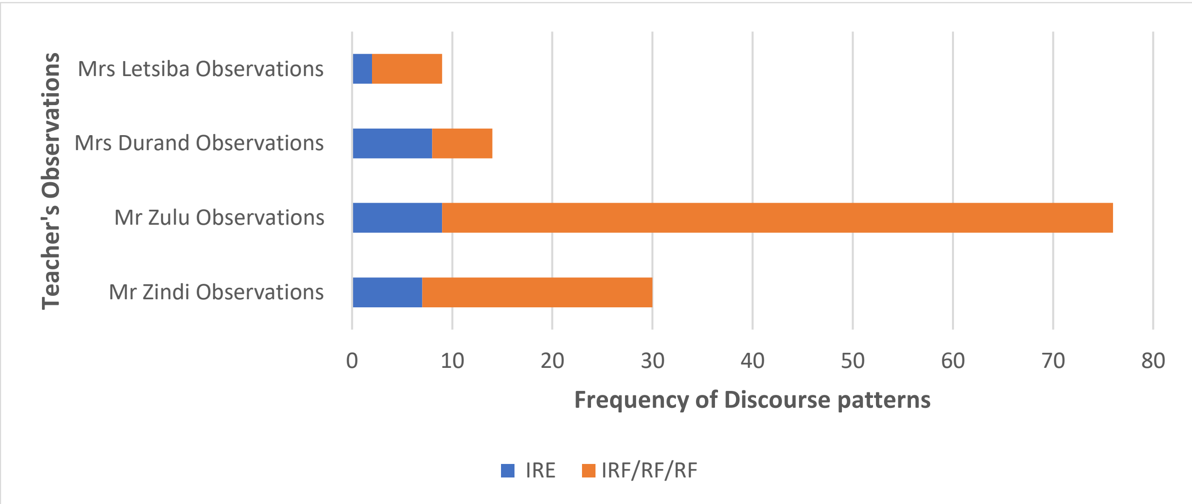


Figure 6. 3: Patterns of Discourse engaged by each teacher and their frequencies

Figure 6.3 shows the I-R-P-R-P-R-P pattern of discourse to be more predominant (with Mr. Zulu recording the most instances) than I-R-E/F. Owing to this, one may be tempted to think that the teachers in this study engaged in dialogic interactions since I-R-P-R-P-R-P chain pattern of Discourse is usually associated with dialogic Discourse (Scott et al., 2006). However, in this study, the chain interactions were mostly associated with authoritative Discourse where the chain was sustained by the teachers' prompts eliciting more answers or ideas from their learners. In this case, the interactions were associated with teachers asking closed questions requiring one-word answers from learners (Mr. Zulu recording the most moments) which according to research have the potential to assist learners to answer algorithms but fail to answer conceptual problems (Surif et al., 2014). This implies that teachers in this study trained their learners well on how to work out genetic problems though they did not train their learners to answer conceptual questions about underlying concepts. For instance, "How do genes determine traits?" and "What is the relationship between gene, allele and trait?" (Haskel-Ittah & Yarden, 2018; Thörne & Gericke, 2014a). The teachers probably assumed that their learners understood these concepts. Patterns of Discourse are usually associated with Discourse moves, hence in the section below I present Discourse moves.

6.6 Teacher Discourse moves

Research has shown that the Discourse moves used by teachers during discussions may play a crucial role in enhancing productive learner-to-learner ideas elicited by initiating questions are important for moving talk and learners' sensemaking (Bansal, 2018; Carpenter et al., 2020; Colley & Windschitl, 2016) and thinking (Bansal, 2018; Thompson et al., 2016). Productive Discourse prompts reasoning ability among learners (Iqbal & Mahmood, 2020). As discussed earlier, I analysed teacher Discourse moves to determine how teachers worked with learners' ideas. Thus, the Discourse moves that were used by teachers in this study are eliciting (eliciting ideas/answers, connection), marking (revoicing, agreeing/disagreeing), building (reasoning, clarification), evaluation (motivation, put-downs) and other (providing information, selecting), these are shown in the in Figure 6.3. It is important to note that building moves (reasoning, clarification) are the most highly rated since they are known for their potential to be productive when it comes to supporting learner conceptual reasoning (Ellis et al., 2019)

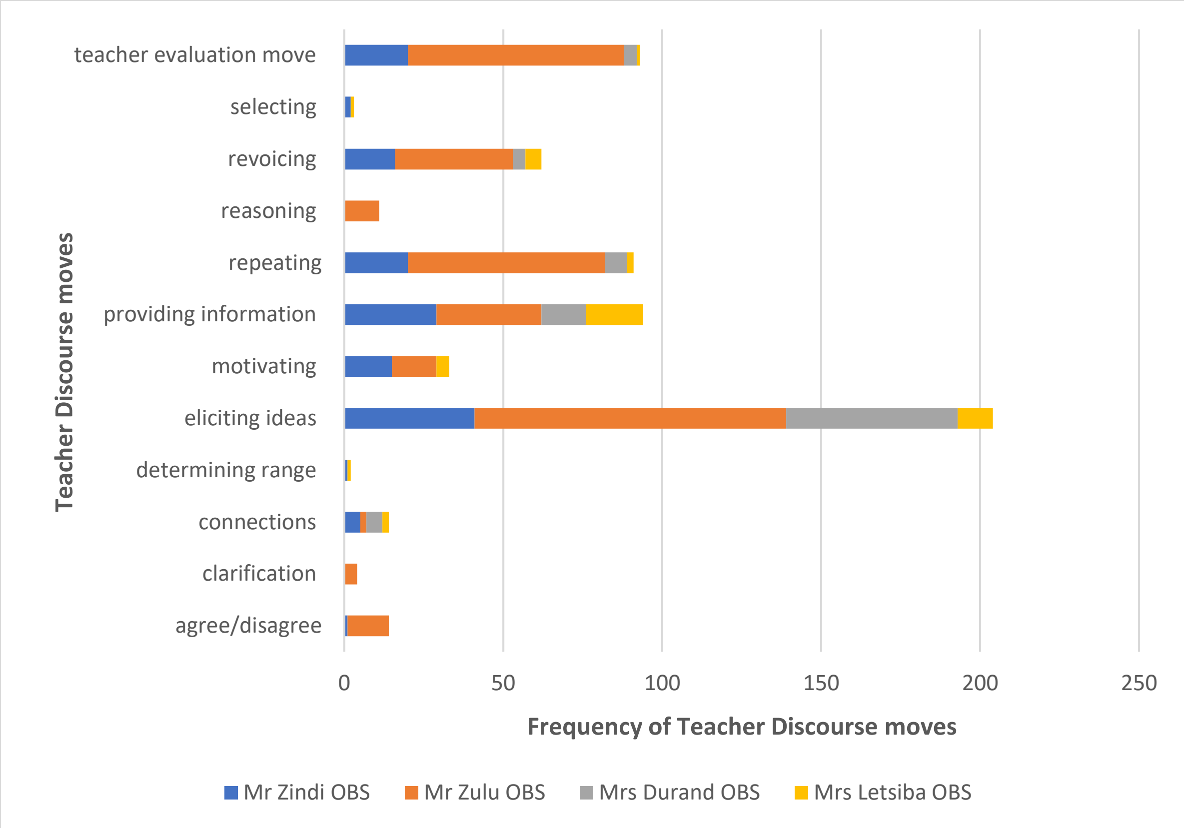


Figure 6. 4: Teacher Discourse moves engaged by each teacher and their frequencies

Figure 6.4 shows that all teachers used the eliciting ideas (most predominant), and connections moves while determining range was only evident in one of Mrs. Letsiba's lessons. Eliciting moves were the most predominant in this study because it was used to elicit ideas and answers during initiation and probing of learners further during the I-R-P-R-P/E chains (which were the most predominant Discourse patterns in this study. As discussed earlier, these moves are categorised as eliciting moves. Figure 6.4 further shows that the marking moves of repeating and revoicing were evident in all classrooms, but the agree/disagree move was only used by Mr. Zulu and Mr. Zindi (once). The interview extract below provides evidence of Mr. Zulus' rationale for using the agree/disagree move during his practice.

224.	*R:*	*Ehm…right so, when…when you were teaching dihybrid inheritance ahh…you gave your learners a problem on shape and colour of the seed.*
225.		*When they were done you then ahh…revised ahh…the question with them.*
226.		*Then ahh…something touched my heart ahh…touched my heart.*
227.		*You asked them to raise their hands if they agree/disagreed with the discussed answer.*
228.		*Why do you use this approach?*
229.	*Mr Zulu:*	*Yaah…ehh…my interest is always in wrong answers 'neh'…because if you see…everything right…those who get everything right I do not have to worry about them ehh…*

230.		*Remember, I have to make sure that ehh…those learners get somewhere…they get to understand the section that aah…I am teaching.*
231.		*So, I have to know who is it that got the answer wrong.*
232.		*So, that…or how many got the answer ehh…wrong so that I can try to use maybe a different approach ehh…in terms of explaining the concept.*
233.		*So, I think my interest is more in those wrong answers.*
234.		*So, that at the end of the day, all of them get the section that I am teaching right.*

Mr. Zulu INT

It is clear from the extract above that Mr. Zulu used the agree/disagree move to identify the learners with wrong answers so he could assist them.

Evaluation moves (positive/negative) were evident in all four classrooms. Nonetheless, this type of praise or encouragement has been criticised because it does not link learners' names to the substantive content in question (Scott et al., 2011). It is sad to note that the reasoning and clarification moves that could be classified as building moves were used only by Mr. Zulu. According to research, the building moves are the most highly rated since they are known for their potential when it comes to supporting learner conceptual reasoning (Ellis et al., 2019). Other moves such as providing information were common to all teachers while the selecting move was only used by two teachers (Mr. Zindi and Mrs Letsiba). Providing information was mostly used by teachers when introducing new ideas. When it comes to the use of the selection move during classroom discussion Mr. Zindi provided the following rationale during his interview session.

186.	*R:*	*Aah…also in one of the videos…in one of the videos, you asked one of your learners to write on the board and you asked one of your learners to draw a diagram on mi—metaphase.*
187.		*What is the importance of doing that?*
188.	*Mr Zindi:*	*That one to me is very important because that helps to consolidate the concepts.*
189.		*The learner that comes and does some work on the board, that concept…that learner will never forget that concept.*
190.		*Even if it comes in the exam or test, the learner will begin to visualise himself the…you know or developing the concept on the board.*
191.		*So, it helps them to understand.*

Mr. Zindi INT

The extract above shows that Mr. Zindi used the selection move for consolidation and providing learners with support in terms of remembering concepts during examinations. In the next section, I present the analysis of the interactive/dialogic communicative approach.

6.7 Interactive/dialogic communicative approach: Analysis

The interactive/dialogic communicative approach unfolds when the teacher listens to, and considers, the learners' points of view, although the views may be different from the scientific view (Scott & Ametller, 2007). In the context of more interactive teaching, dialogic interactions often occur when the teacher tries to elicit learners' views as shown in the following example.

LO1: Recapping meiosis and abnormal meiosis

This dialogic interaction occurred in Mrs. Letsiba's lesson observation 1 when she was recapping meiosis and focusing on meiosis. The Dialogic interaction presented in the except below was extracted from an episode that was generally characterised by authoritative interactions where the teacher dealt with genetics terminology[8]: This episode was associated with I-R-E/F, I-R-P-R-P chain Discourse pattern where the teacher used the eliciting, repetition, elaboration moves and I-R_1-R_2-R_3-R_4-F where Mrs. Letsiba used the eliciting and determining range moves. In this case, the subscript represents a response from a specific learner which is attended to by another learner instead of the teacher. However, there were two instances where the teacher engaged in the noninteractive/authoritative communicative approach where the Discourse pattern was telling with the teacher using the providing information move to deal with the terminology listed above.

87.	*Mrs. Letsiba:*	*Anyone to help ehh…ehh…/ ? /…what is happening during metaphase 1?*
88.	*Ameirie:*	*I am saying it forms ehh… ehh…the spindle threads.*
89.	*Ls:*	*[Laughing]*
90.	*Mrs. Letsiba:*	*Anyone to help!*
	[Noise]	
91.	*Mrs. Letsiba:*	*No! Anyone to help?*
	[Noise]	
92.	*Mrs. Letsiba:*	*Can you wait…ehh… I want you to help him just explain what ehh…metaphase 1 is all about neh ("isn't it" in Afrikaans) …anyone…*
	[Noise]	
93.	*Sifiso:*	*Ma'am like ehm…the chromosomes align themselves along the equator in homologous pairs in metaphase 1 but then in metaphase 2 they align themselves as singly meaning…/ ? /*
	[Noise]	
94.	*Mrs. Letsiba:*	*Ehh…one person at a time ehh…Lethabo*

[8] meiosis, centriole, centrosome, centromere, chiasmata, crossing over, prophase 1 and 2, nuclear membrane, maternal, paternal, genetic material, bivalent, daughter cells, random assortment, chromosomes, variation, metaphase 1 and 2, spindle fibres, homologous pairs, chromatids, meiotic division 1 and 2, cell, haploid, nucleus, cytokinesis, cytoplasm, telophase 2 and mitosis.

95.	*Lethabo:*	*In metaphase 1 neh (“isn’t it” in Afrikaans)…they align themselves in [using hands]*
96.	*Mrs. Letsiba:*	*Can you come?* *[Lethabo goes to the board]*
97.	*Lethabo:*	*Eeh…madam!*
98.	*Mrs. Letsiba:*	*I AM not a priest!*
99.	*Ls:*	*[Laughing]*
100.	*Lethabo:*	*Madam /we can ask a question/ is there one difference in metaphase 1 and in metaphase 2?*
101.		*I say yes because in metaphase 1 ma’am [drawing on the board] these are centrioles, spindle fibres.*
102.	*Kamogelo:*	*Spindle fibres.*
103.	*Lethabo:*	*Okay [drawing on the board] …these are your homologous pairs right they are lining pairs…pairs neh (“isn’t it” in Afrikaans) …and then in metaphase 2 it’s are no more in pairs, [erasing the other chromosome from the diagram] its singly…one chromosome… [smiling and using hands] …you understand what I am saying?*
104.	*Mrs. Letsiba:*	*Ehh… let us hear from ehh… [points to a learner]*
105.	*Chinasa:*	*What then happens… what then happens to the [chromosomes] ?*
106.	*Lethabo:*	*It did not— it did not disappear angisho— [“isn’t it” in IsiZulu]*
107.	*Mrs. Letsiba:*	*They just ehh…*
108.	*Kamogelo:*	*Went to the centrioles.*
109.	*Mrs. Letsiba:*	*Is it not that they were in what…ehh…was a marriage between them … And then ehh… when [moving close to Jeremy and holds his hand as he stands up] I am getting married to Jeremy.*
110.		*Every now and then when I am moving, I am moving…I am moving with Jeremy ‘neh’... that is ehh… our meta- phase 1… going with Jeremy to--ehh… to the equator and I am not going alone.*
111.		*Is it not so…he is my partner?*
112.		*So, we must do what…we must GO ehh… toge-ther … and then at some point [learners laugh] Jeremy is not doing the right thing then I am doing what…I am—I am ehh…divorcing ehh…Jeremy.*
113.		*So, when I am divorcing Jeremy then it is /metaphase/ what…*
114.	*Ls:*	*2!*
115.	*Mrs. Letsiba:*	*…ehh…2 when chromosomes are moving what…all over the place…what…ehh… ((in single))*
116.	*Lethabo:*	*Ma’am can you please start in telophase one— one whereby one cell it now has ehh…haploid?*
117.	*Mrs. Letsiba:*	*Ah…ahh…okay…I just wanted to make you understand ‘neh’...*
118.	*Lethabo:*	*^I am being moved.*
119.	*Mrs. Letsiba:*	*[Low tone] Oh! Um—*
120.	*Lethabo:*	*…’coz I mean she [referring to Chinasa] asked, where did the other chromosomes go?*
121.		*So, I am referring her [Chinasa] to telophase:se 1.*
122.	*Mrs. Letsiba:*	*Ohoo…okay.*

Mrs. Letsiba LO1, episode 1

Transcription conventions used in this transcript are explained in Table 4.2 in Chapter 4.

Communicative approach

The interaction above started with a question posed by Mrs Letsiba (turn 87) in a bid to elicit learners’ views. This question was asked with the clear purpose of eliciting different ideas (turns 88, 93, 95, 100, 101, 102, 103,106, 108, 116, 120) from her learners. This is evidenced by the teachers’ non-evaluative responses. What is interesting in this episode is how Mrs.

Letsiba juxtaposed the everyday and scientific views (turns 109-113) as she used marriage and role play to discuss the events of metaphase 1. Mrs. Letsiba's tactic can be considered a useful link-making pedagogical tool used by the teacher to promote knowledge-building (Scott et al., 2011). This is shown by the fact that learners were no longer interested in pursuing the concept of metaphase 1 but rather Lethabo asked the teacher to move onto the next phase telophase (turn 116). Thus, Mrs. Letsiba allowed her learners to position the scientific views of the subject matter in relation to their everyday views, thus making it their own.

In this excerpt, Mrs. Letsiba used open chains of interaction without evaluative feedback to encourage an interactive/dialogic communicative approach, to probe learners' views. By adopting an interactive/dialogic communicative approach, Mrs. Letsiba created a conducive environment for "productive disciplinary engagement" (Engle & Conant, 2002). This became evident as a notable number of learners actively participated as they made substantive and emotional (turn 118) contributions to the discussion. Dialogic interactions may trigger or support learners' interest (Juuti et al., 2020) as evidenced in turn 118 when Lethabo said "*I am being moved"* in a high-pitched voice after Mrs. Letsiba used a different view from the science view in a bid to answer Chinasa's question (turn 109) inquiring where the chromosomes go during metaphase 1 (turn 105).

The pattern of Discourse and Teacher Discourse Moves

I-R-P-R-P-R… open chain

Mrs. Letsiba initiated the discussion with a question: "*Anyone to help ehh…ehh…what is happening during metaphase 1?"*. [Initiation] Ameirie responded by saying "*I am saying it forms ehh… ehh…the spindle threads.*" [Response] is followed by Mrs. Letsiba's request for elaboration from the class, "*Anyone to help? Can you wait…ehh… I want you to help him just explain what ehh…metaphase 1 is all about neh…anyone…*" [Prompt]. Sifiso tries to help by saying "*Ma'am like ehm…the chromosomes align themselves along the equator in homologous pairs in metaphase 1 but then in metaphase 2 they align themselves as singly meaning…"*. [Response] The teacher did not evaluate the answer but instead opened up the discussion even further as she reprimanded the class (making noise) and prompted Lethabo by saying "*Ehh…one person at a time ehh…Lethabo*" [Prompt]. Lethabo responds whilst using hands "*In metaphase 1 neh…they align themselves in…*" [Response]. Mrs. Letsiba interpreted Lethabo's actions as showing that she wanted to demonstrate on the board and said "*Can you come"* [Prompt]. At the board, Lethabo started by asking a question which she answered in turns (100, 101, 103) as she drew a diagram on the chalkboard. After Lethabo’s response, the teacher did not make an evaluation but rather probed the class further until turn 108 as the chain continued. Throughout the excerpt, Mrs. Letsiba neither evaluated nor elaborated on learners' responses but rather maintained a neutral stance as she elicited more ideas from them. Unlike Mr. Zindi, Mrs. Letsiba was not eliciting correct answers from her learners but ideas which made her moves more supportive in terms of learners’ conceptual reasoning (Ellis et al., 2019). The following extract from Mrs. Letsiba’s interview provides the rationale behind engaging in the type of Discourse where she allowed her learners to do the talking. (‘R’ represents the researcher in the interview transcripts)

253.	*R*	*I saw that you allow learners to debate on their own… you are quiet, and they are busy you know, asking each other questions and answering on their own.*
254.		*Why do you think this is important?*
255.	*Mrs Letsiba:*	*Ehh…this is very important to me ma’am.*
256.		*As I am saying that ehh… at the same time I am forcing them to read.*
257.		*I am forcing them to study.*
258.	*R:*	*Ehm.*
259.	*Mrs Letsiba:*	*You understand!*
260.	*R:*	*Ehm.*
261.	*Mrs Letsiba:*	*Hence I am saying ehh… I am running away ehh… from that ehh… teacher-centred ehh… approach.*
262.	*R:*	*Ehm.*
263.	*Mrs Letsiba:*	*Also, learners, they need to be independent.*
264.		*So, I give them the space.*

Mrs. Letsiba INT

For Mrs. Letsiba engaging in interactions involving open chains forces her learners to study, provides them with space and allows them to be independent. Furthermore, it is her way of moving away from the teacher-centred approach. The teacher was asking questions to prompt her learners into elaborating and justifying their ideas instead of evaluating them. These moves asking learners for clarification and justification or reasoning are classified as building moves (Carpenter et al., 2020) and are known for their high potential for supporting learners’ conceptual reasoning (Ellis et al., 2019; Howe et al., 2019). Such probing moves are not evaluative (Lim et al., 2020) but are known for their ability to push learners' thinking further (Bansal, 2018; Colley & Windschitl, 2016). Thus, I can conclude that Mrs. Letsiba was the only teacher in this study, who pushed her learners’ thinking further since her feedback was not evaluative and afforded her learners more support for conceptual reasoning. Below, I discuss the communicative approach, patterns of Discourse and teacher Discourse moves that unfolded in a closed I-R-P-R-P-R-E chain.

I-R-P-R-P-R-E closed chain

Mr. Zulu LO2: Genetics and inheritance

A dialogic interaction unfolded in Mr. Zulu's episode 4 of Lesson Observation 2 turns (326-337) where he was teaching Mendelian crosses as shown below. The following excerpt was extracted from an episode which started as a dialogic interaction and shifted to a noninteractive/dialogic communication when Mr. Zulu was focusing on the terms; *offspring, genetic makeup, inherit, allele, mutation, genetics, dominant, gene and mutation.* When focusing on this terminology, the Discourse pattern took the I-R-P-R-P chain and shifted to a telling form where Mr. Zulu used the eliciting, connections and providing information moves. (Transcription conventions like up arrows are explained in Table 4.2 in Chapter 4).

326	*Ashley:*	*Sir, what if ehh…both parents are short and the offspring is tall, what happens in the genetic makeup?*
327.	*Ls:*	*[Laughter]*
328.	*Mr. Zulu:*	*Okay [laughingly] you know it is possible "neh"…okay it possible… you find that the parents are both short and then the… offspring is tall okay.*
329.		*So, boys what do you think?*
330.	*Ls:*	*[Laughter]*
331.	*Mpho:*	*Maybe they will tell-- maybe your parents will tell you like you inherited it from your grandfather.*
332.	*Mr. Zulu:*	*Okay, yes if we try to explain it in an African way…*
333.	*Ls:*	*[Laughter]*
334.	*Lesedi:*	*/ ? /*
335.	*Mr. Zulu:*	*/ ? / …an allele okay, you still remember mutations.*
336.	*Ls:*	*Yes!*
337.	*Mr. Zulu:*	*Okay, you know mutations can be good as well we said that.*
338.		*So, yes in some cases they can be because of a mutation.*
339.		*Just a slight change in the genetic sequence okay can cause that okay…and you can find that the two parents are dark, but the child is light in complexion.*
340.		*↑You are not going to say that it is not your child…*
341.	*Ls:*	*[Laughter]*
342.	*Mr. Zulu:*	*Okay, it can because of a mutation, just a slight change in the genetic makeup…right.*
343.		*So, it does happen…it does happen or maybe both your parents are - they are light in complexion then wena ["you" in IsiZulu] you become very dark.*
344.	*Ls:*	*[Laughter]*
345.	*Mr. Zulu:*	*This can be the explanation "neh"…you know…this can be an explanation it can happen that yes, you could be light because maybe light was dominant over darkness but both of your parents have genes for darkness.*
346.		*In some cases, you can find that they do not have genes for that but then because of what we call mutations just a slight change in genes or change in genetics effects and then wena ["you" in IsiZulu] you become ehh…dark…it does happen "neh" okay.*
347.		*So, even with the short parents giving birth to someone who is tall okay….it is possible…okay…and also again boys, there are other conditions that can influence that, like for example the things that we eat nowadays.*

348.	*You find that our parents are short but thina [“we” in IsiZulu] we are very tall okay.*
349.	*It is also things that ehh…hormones from the foods that we eat…okay but we will look at hormones at a later stage…okay.*

Mr. Zulu LO2, episode 4

Communicative approach

The episode above started with a genuine question posed by Ashley (turn 326) which was thrown back to the learners by the teacher (turn 328) as he tried to elicit learners’ views. Mr. Zulu considered a different point of view (turn 331, 332) from another learner and introduced the scientific view (turn 337). Mr. Zulu listened to his learners and allowed them to express their views freely (turn 331, 332). Ashley’s question enabled learners, through discussion, to make connections between everyday and scientific views. That being the case, Ashley’s question can be considered a useful link-making pedagogical tool used by the teacher to promote knowledge building (Scott et al., 2011). In this episode it can be noted that Ashley’s question was successful not only in drawing attention to the different points of view but also in helping the teacher juxtapose everyday and scientific views (Scott et al., 2011) (turns 332, 335) as he accepted the Mpho’s explanation as “*…the African way”* (turn 332) and introduced the concept of “*…mutations”* (turn 335). Like (Scott et al., 2006), I believe that it is important for supporting meaningful learning by learners. As a result, Mr Zulu allowed his learners to position the scientific views of the subject matter in relation to their everyday views, thus making it their own. In addition, by adopting an interactive/dialogic communicative approach, Mr Zulu set a suitable environment for “productive disciplinary engagement” (Scott et al., 2006), which became evident as learners became involved in making substantive contributions to the discussion. Though Mr Zulu opened up the Discourse to his learners it looks like he was faced with a challenge in terms of what to do next as he quickly intervened and called the discussion to a close by introducing the scientific point of view. This challenge is referred to as ‘tension’ (Scott et al., 2006) or ‘internal struggle’ (Lehesvuori et al., 2019) which exists when the teachers adopt the dialogic approach as they encourage learners to make their views explicit while paying attention more authoritatively to the accepted scientific point of view. Perhaps without this tension, Mr Zulu’s interaction with his learners could have become more dialogic and interactive. Overall, comparing the four teachers in terms of this approach, Mr. Zulu, and Mrs Letsiba’s practices were better than Mrs. Durand and Mr. Zindi’s in the sense that they considered their learners’ ideas during the development of the scientific views.

Mrs. Letsiba and Mr. Zulu's classrooms were characterised by shifts in the communicative approaches from authoritative to dialogic. These shifts are essential in supporting or triggering interest and meaningful learning of scientific concepts and serve a particular purpose at a given point of the lesson (Scott et al., 2006) though teachers rarely engage in dialogic interactions. When learners are allowed to engage in dialogic exploration of ideas, this must be followed by and authoritative approach where the teacher isolates and clarifies the scientific point of view (Scott & Ametller, 2007). For instance, in the case of Mr. Zulu discussed above, he allowed learners time for dialogic exploration of their ideas and closed the discussion by clarifying the scientific view. This way, the dialogic talk prompted the teachers' need for intervention while authoritative talk acts as a seed for dialogic exchanges when exploration of ideas follows the authoritative development of the scientific view (Scott et al., 2011). Thus Mrs. Letsiba's and Mr. Zulu's practices were better than the other two teachers in this regard.

The pattern of Discourse and Teacher Discourse moves

I-R-P-R-E Closed chain

The excerpt above shows an interaction that was initiated by a learner (Ashely) when he asked the question "*Sir, what if ehh…both parents are short and the offspring is tall, what happens in the genetic makeup?*" [Initiation]. Mr. Zulu responded to the learner's question "*Okay [laughingly] you know it is possible "neh"…okay it possible… you find that the parents are both short and then the… offspring is tall okay*" [Response] but bounced the question back to the class "*So, boys what do you think?*" [Probe]. Mpho responded, "*Maybe they will tell--maybe your parents will tell you like you inherited it from your grandfather*" [Response]. Then Mr. Zulu closed the interaction "*Okay, yes if we try to explain it in an African way…*" [Evaluation]. What is unique in this case is that the interaction was initiated by a learner and then the teacher opened up the chain but quickly closed it up by evaluating the learners' response. He was probably caught up in the tension between the dialogic and authoritative Discourse (Scott et al., 2006) as evidenced by his shift from dialogic to authoritative Discourse (turns 335-349). Thus, the dialogic Discourse did not last long because of the evaluative nature of the teacher's feedback. To sustain the Dialogic discourse the teachers' feedback need not be evaluative (Lim et al., 2020). If Mr. Zulu had not evaluated the learner's (turn 332) feedback, probably the Discourse chains could have been opened more and the interaction could have been more dialogic. Comparing Mr. Zulu's to Mrs. Letsiba's practice presented earlier in terms of their communicative approaches, it is clear that Mrs. Letsiba's was more dialogic. This is due to the Discourse chains being more open and extended with no evaluative feedback. While eliciting moves is vital in assisting teachers to understand what learners know and understand, they are known for their lower potential for supporting learners' conceptual understanding (Ellis et al., 2019) than building moves which elicit learners' reasoning and justification of their responses (Carpenter et al., 2020). Thus, the moves used by Mr. Zulu were meant to elicit ideas and make connections (turn 329) only without exploring them. Though Mr. Zulu engaged in a dialogic interaction, he did not afford his learners more support for conceptual reasoning. In the next section, I present an analysis of the interactive/authoritative approach.

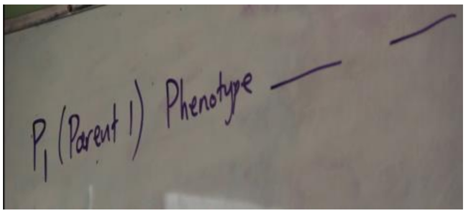
6.8 Interactive/authoritative communicative approach: Analysis

This approach is characterised by teachers paying attention to only one point of view while excluding the learners' participation (Scott & Ametller, 2007). The sequences below provide an example of the scenario where this type of communicative approach was evident.

Mr. Zindi LO3: Genetics and inheritance

The interactive/authoritative communicative approach unfolded in episode 2 of Mr. Zindi's Lesson Observation 3 where he focused on genetic crosses using Mendel's experiments as shown below. This approach was evident in an episode that had equal numbers of scenarios of both the noninteractive/authoritative and interactive/authoritative communicative approaches. These approaches were used when the teacher was focusing on genetics terminology[9]: In dealing with this terminology, Mr. Zindi's Discourse alternated between telling and I-R-F or I-R-P-R-P-R-P chain pattern where he used the providing information, eliciting, repeating, evaluation and teacher elaboration moves.

47.	*Mr. Zindi:*	*So, parent 1, what do you look at in parent? [Erases the word parent]*
48.		*First of all, you start with the phenotype.*
49.		*P_1 means parent 1...phenotype.*
50.		*Then these parents they have phenotypes.*



[9] genetic cross, F_2 generation, pure breed, genetic diagrams, co-dominance, dominance, complete dominance, incomplete dominance, true breeding, self-pollinate, phenotype, breeding, offspring, monohybrid cross, P_1, genetic make-up, fertilization, gametes, gametogenesis, meiosis, genotype, sperm cells, eggs, mammals, ovules, pollen grains, and reproduction.

51.		*Do you still remember what genotype means?*
52	*Ls:*	*Yes, sir!*
53.	*Mr. Zindi:*	*What is it?*
54.		*Who can quickly tell us, what is genotype?*
55.	*Sibusiso:*	*It is the genetic makeup of an organism.*
56.	*Mr. Zindi:*	*That is correct!*
57.		*The genetic makeup of an organism.*
58.		*So, the next step is … then P_1 genotype…you have this P_1 phenotype…[writing]*
59.		*Now you have your two parents…they are in love and are going to make babies…*
60.	*Ls:*	*[Laughter]*
61.	*Mr. Zindi:*	*…what needs to happen there because they are going to … what happens next?*
62.	*Ls:*	*Fertilization!*
63.	*Mr. Zindi:*	*Fertilization will take place.*
64.		*What is involved with fertilization? Yes!*
65.	*Sipho:*	*The gametes… [unclear]*
66.	*Mr. Zindi:*	*Yes! Pardon!*
67.	*Sipho:*	*The gametes …*
68.	*Mr. Zindi:*	*The gametes, right now these gametes must be formed first.*
69.		*What is the process that is involved in the formation of gametes?*
70.	*Joseph:*	*Gametogenesis!*
71.	*Mr. Zindi:*	*Gametogenesis, occurs in which process?*
72.	*Sifiso:*	*Meiosis!*
73.	*Mr. Zindi:*	*In meiosis, the cell chosen occurs first.*

Mr. Zindi LO3, episode 2

Communicative approach

The turns above show how Mr. Zindi led his learners through a sequence of questions (61, 64, 69, and 71) and answers (62, 65, 67, 70, and 72) to get a single specific view on how to work out a genetic cross. He was only interested in his learners getting the steps of doing a genetic cross right not opening up to other ways of doing it. Furthermore, turns 62, 65, 67, 70, and 72 show that though the learners were allowed to participate in the discussion, their contributions were only limited to one-word answers. This implies that there was less exploration of ideas (Scott et al., 2006) which may be considered as a productive practice for learning conceptual knowledge which involves link-making.

Mr. Zindi did not ask his learners their ideas about presenting a genetic cross but expressed their understanding of the scientific view (genetic cross) with the teacher supporting and guiding them. It is evident from the learners' responses that they understood what the teacher was asking. The Discourse presented in the excerpt is strictly authoritative as shown Mr. Zindi's statements before the interactions (turns 47-50) are authoritative manner. Mr. Zindi', statements "*First of all, you start with the phenotype. P_1 means parent 1.*" and the notes he wrote on the board signal the authoritative nature of discussion, something that learners were expected to accept and follow. Similar observations were made in Mrs Durand's classroom.

Furthermore, Mr. Zindi (turn 59) linked the science view to the natural phenomenon of mother and father being in love and making babies. This is important as it assists learners with link-making (Scott et al., 2011). Nonetheless, if the interactions in the classroom are focused entirely on the authoritative presentation of scientific knowledge by the teacher, it then becomes more difficult for learners to engage in a meaningful way with the concepts of the lesson (Scott et al., 2011). Consequently, in this study, Mr. Zindi and Mrs. Durand engaged in authoritative Discourse as they shifted from an interactive/authoritative to a noninteractive approach. Thus, their teaching may be considered as bad since it did not engage learners in a meaningful way with the concepts.

The pattern of Discourse and Teacher Discourse moves

I-R-E/F pattern

The excerpt shows Mr. Zindi starting the interaction with a question "*Who can quickly tell us, what is genotype?* [Initiation] Sibusiso answered "*It is the genetic makeup of an organism*" [Response]. Mr. Zindi then evaluated the learner's answer and repeated it "*That is correct! The genetic makeup of an organism*" [Evaluation]. Here, it can be noted that the learner's contribution is short and strongly linked to the teacher's feedback. The I-R-E/F pattern is known for shaping Learners' ideas, selecting ideas as the teacher provides feedback, sharing ideas, marking key ideas, checking to understand, and reviewing covered work (Salloum & BouJaoude, 2019). Thus, the discussion above suggests that Mr. Zindi reviewed and checked understanding by creating an environment that allowed his learners to share their ideas about the term genotype, as he marked the key idea by repeating the learner's response. It is clear that this interaction shown in the excerpt above started as an I-R-E/F pattern and shifted into an I-R-P-R-P-R-P-R-P-R-E long closed chain (turns 61-73). In some of the feedback, the teacher simply bounced the learners' words to the class "*Fertilization will take place. What is involved with fertilization? Yes!*" (Turns 64, 65). In this way, Mr. Zindi Sustained the interaction and seemed to foreground his learners' answers by repeating them. It is also not clear whether the teacher was evaluating his learners' answers negatively or positively or was making a move to elicit answers by repeating their answers. Nonetheless, it appears clear that the responses from Sipho, Joseph and Sifiso (Turns 67, 70, 73) were being positively evaluated by the teacher. Furthermore, an important point which arises here is that the teacher's objective was to check the learners' understanding of the school science. The interactions presented in this excerpt not supposed to be mistaken for an interactive/dialogic communicative approach because of the absence of evaluation by the teacher which would mean the teacher was exploring learners' views. Overall, in this excerpt, Mr. Zindi used several Discourse moves in collaboration in a sustained effort to check his learners' understandings of the school science view about the genetic cross.

More specifically, Mr. Zindi consistently employed the move of eliciting direct answers about working out a genetic cross (Turns 53, 54, 61, 64, 69, 71), that were not the learners' own ideas. This move of eliciting answers from the learners is known for its low potential for supporting learners' conceptual reasoning (Ellis et al., 2019). Furthermore, the excerpt shows that he employed marking moves of repetition (57, 71, 73), revoicing (63, 68) learners' responses and evaluation moves of motivating (56) without following up with other moves such as building moves to elicit information about the underlying concepts like meiosis and reproduction from his learners. As such, his learners were not afforded opportunities to elaborate on or justify their reasoning, or explain how their ideas resonated with or differed from those of their colleagues. It is clear that Mr. Zindi only employed eliciting, marking and evaluation moves which have the potential to assist learners in answering algorithms (genetic cross) but fail to answer conceptual problems (Surif et al., 2014). In their practices Mr. Zindi like Mrs. Durand did not have as sustained an effort to engage learners in sensemaking as Mr. Zulu and Mrs. Letsiba did in the dialogic interactions examples discussed above. Mrs. Letsiba went beyond eliciting learners' responses and worked with their ideas by eliciting their reasons for their responses.

In terms of evaluation moves, Mr. Zindi had motivation (turn 56) and put-downs during his practice. He had this to say about evaluation during his interview session. ('R' refers to the researcher in the interview transcriptions).

192.	*R:*	*There is a time in of the lessons where you responded to your…to your learner by saying 'That's a very good observation' with loudness…in other words you were affirming that what this child was saying is correct.*
193.		*What is the importance of doing that?*
194.	*Mr Zindi:*	*Yaah…ehh…it is very important because it ehh…increases motivation in the learner because ahh…any person feels very happy if he/she does something ehh…good and people appreciate…so that kind of appreciation, that kind of recognition will encourage a learner to do more and also encourage others to do the same.*

Mr. Zindi INT

According to Scott et al. (2011) the generic type of praise employed by Mr. Zindi in his practice *'That's a very good observation'* has been criticised since it is not linked to substantive content. In this study, this type of praise and encouragement was used by all teachers. Instead, the one encouraged would be one where the teacher links a specific point of view raised by a learner and that learner's name (Scott et al., 2011).

Put-downs in this study refer to the negative feedback given to learners by teachers for instance, *'That's not correct!'*. A similar type of feedback was also evident in Mr. Zulu's classroom, where he would simply say '*No!*' in response to a learner's answer. Mrs. Durand and Mrs. Letsiba did not use these put-downs. During his interview, Mr. Zindi had this to say regarding put-downs.

197.	*R:*	*Also, in your practice, you use evaluation like you…you directly say 'That's not correct!*
198.		*What is the importance of doing that?*
199.	*Mr Zindi:*	*Aah…I think that is not the best way, I would say because when a learner gives you a wrong answer, you need to appreciate first rather than just say 'that is not correct'.*
200.		*You…you appreciate, thank you for your contribution but however, we see it differently and probably ask another learner to ehh…explain ehh…better.*
201.		*So, I think to just say that is not correct is not the best way forward.*
202.	*R:*	*Yaah…you…you…sorry!*
203.	*Mr Zindi:*	*Because when…when you ask a learner a question, you are not always expecting a correct answer*
204.	*R:*	*Ehm.*
205.	*Mr Zindi:*	*You are simply asking the learner's opinion which can be correct, or wrong.*

Mr. Zindi INT

The two excerpts above resonate with Mr. Zindi's authoritative nature of his practice. As discussed earlier, it is clear that his objective for interacting with his learners was to elicit their understanding (Turns 194, 199, 200) of the scientific view of the concepts in question. Though Mr. Zindi acknowledged that when asking questions, the objective is to elicit learners' opinions (Turn 205), not correct answers (Turn 205), it is clear from the excerpt above that what he said refuted what he practised because he was simply looking for correct answers, not learners' opinions.

6.8 Noninteractive/dialogic communicative approach: Analysis

As discussed earlier in section 6.3, a noninteractive/dialogic approach occurs when the teacher recaps or summarises different viewpoints by solely listing them or exploring the similarities and differences between the viewpoints (Scott & Ametller, 2007). This approach was only used by Mrs. Letsiba and Mr. Zulu in this study. The noninteractive/dialogic approach unfolded as a shift from an interactive/dialogic approach which was initiated by the following question from Ashley "*Sir, what if ehh…both parents are short and the offspring is tall, what happens in the genetic makeup?"* discussed in the except presented under interactive/dialogic communicative approach section above. Here Mr. Zulu was focusing on Ashley's question presented above. When responding to the question, the teacher focused on the following terminology: *offspring, genetic make-up, inherited, allele, mutation, genetics, dominant, gene and hormones.* The response was associated with the telling Discourse, where the teacher used the providing information move to explain how short parents may have tall offspring.

Mr. Zulu LO2: Genetics and inheritance

335	*Mr. Zulu:*	*/ ? / ...an allele okay, you still remember mutations.*
336.	*Ls:*	*Yes!*
337.	*Mr. Zulu:*	*Okay, you know mutations can be good as well we said that.*
338.		*So, yes in some cases they can be because of a mutation.*
339.		*Just a slight change in the genetic sequence okay can cause that okay…and you can find that the two parents are dark, but the child is light in complexion.*
340.		*↑You are not going to say that it is not your child…*
341.	*Ls:*	*[Laughter]*
342.	*Mr. Zulu:*	*Okay, it can because of a mutation, just a slight change in the genetic makeup…right.*
343.		*So, it does happen…it does happen or maybe both your parents are - they are light in complexion then wena ["you" in IsiZulu] you become very dark.*
344.	*Ls:*	*[Laughter]*
345.	*Mr. Zulu:*	*This can be the explanation "neh"...you know…this can be an explanation it can happen that yes, you could be light because maybe light was dominant over darkness but both of your parents have genes for darkness.*
346.		*In some cases, you can find that they do not have genes for that but then because of what we call mutations just a slight change in genes or change in genetics effects and then wena ["you" in IsiZulu] you become ehh…dark…it does happen "neh" okay.*
347.		*So, even with the short parents giving birth to someone who is tall okay….it is possible…okay…and also again boys, there are other conditions that can influence that, like for example the things that we eat nowadays.*
348.		*You find that our parents are short but thina ["we" in IsiZulu] we are very tall okay.*
349.		*It is also things that ehh…hormones from the foods that we eat…okay but we will look at hormones at a later stage…okay.*

Mr. Zulu LO2, episode 4

The except above shows Mr. Zulu taking a noninteractive/dialogic communicative approach, to talk through the point of view raised by Mpho during the interactive/dialogic approach presented earlier. In this case Mr. Zulu, links Mpho's point of view to the science point of view by saying " *You are not going to say that it is not your child…"* (turn 340) after presenting the concept of mutations (turns 337-339). He therefore linked certain substantive ideas (turns 337-339) with his learners (turn 340) and used vernacular (IsiZulu) (turns 343, 346, 348) hence encouraging emotional engagement (Scott et al., 2011). As the teacher introduced the science viewpoint, he also considered other ideas like "*hormones from the* *foods"* (turn 349) as causing short parents to have tall offspring. A similar observation of linking certain substantive ideas to learners (names) was made in Mrs. Letsiba's lessons when she referred to Mario (her learner) and his mother when focusing on the concept of phenotype. When asked in her interview, why she used that approach during her teaching, Mrs. Letsiba had this to say.

167. Mrs Letsiba: So, I am—[using] those scenarios… I am just using them so that they do what… they do understand.

Mrs. Letsiba INT

The interview excerpt shows that Mrs. Letsiba understood that linking learners' names to the substantive ideas in question helps her learners to understand. Since encouraging emotional engagement is linked to link-making (Scott et al., 2011), it follows that Mr. Zulu and Mrs. Letsiba provided their learners with support for making links between existing and new ideas which is important for learning conceptual knowledge.

A closer look at the excerpt presented earlier in the interactive/dialogic section and the one presented in this section shows that Mr. Zulu used an interactive/dialogic approach when making connections between everyday and scientific views which then disappeared as he developed the science view. However, this is in contrast to Mrs. Letsiba whose Discourse became dialogic when she was attending to the science view, which is strongly recommended by Scott et al. (2011) who argue that the teacher could encourage learners to explore links between science concepts as they engage in dialogic interactions.

Patterns of Discourse and Teacher Discourse moves

The excerpt above shows Mr. Zulu doing all the talking as he tries to answer Ashley's question Ashley "*Sir, what if ehh…both parents are short and the offspring is tall, what happens in the genetic makeup?"* by juxtaposing the everyday view provided by Mpho "*Maybe they will tell-- maybe your parents will tell you like you inherited it from your grandfather*" and the science view. The Discourse pattern evident in the excerpt above is exposition or telling and the Discourse moves emerging from the teacher's talk are providing information and connections. Here Mr. Zulu reformulated the key argument established in the prior discussion as he channelled the Discourse towards the established scientific view (Bansal, 2018) about mutations. Providing information as a move is known for its low potential for supporting learners' reasoning (Ellis et al., 2019) while the connections move is known for supporting knowledge building by linking the scientific view to everyday views (Scott et al., 2011). Though Mr. Zulu did not provide his learners with support for conceptual reasoning, he provided them with support for link-making.

6.9 Non-interactive/authoritative communicative approach: Analysis

This approach is characterised by teachers paying attention to only one point of view while excluding the learners' participation (Scott & Ametller, 2007). The sequences below provide an example of the scenario where this type of communicative approach was evident.

Mrs. Letsiba LO2: Genetics and inheritance

The non-interactive/authoritative communicative approach unfolded in episode 5 of Lesson Observation 2 where Mrs. Letsiba was introducing new terminology associated with the topic of genetics and inheritance. In this episode, Mrs. Letsiba engaged in a noninteractive communicative approach to introduce the following concepts: *genetics, inheritance, genes, father of genetics, fertilization, chromosomes, paternal maternal, egg, spermatozoan, zygote, allele, co-dominance, phenotype, genotype, and genetic make-up.* This introduction was conducted in a telling Discourse pattern where Mrs. Letsiba used the providing information move.

46.	*Mrs. Letsiba:*	*And so, Gregor Mendel as the Austrian ehh…monk…he was using ehh…THE ehh…pea ehh…plants.*
47.		*He was using the pea plants… [writing on the board] … and I have said to you what…we need to know whenever we talk about the allele…what is ehh…the allele…?*
48.		*When we are talking about the ehh…co-dominance what is the ehh…codominance neh ("isn't it" in Afrikaans)….*
49.		*You look at madam Letsiba [referring to herself]…and you are able to do what…to describe me…you understand…that is my PHENO-TYPE…*
50.		*But before we can even talk about ehh…that phenotype …we have what---THE— theehh…GENO— ehh…TYPE… [writing on the board] what…the genotype…the meaning of ehh…the genotype is the genetic makeup of an organism…the genetic makeup of an organism… [moving towards the learners]*
51.		*And then we what-- which means it is that ehh…it is this genotype that will bring [using open hands] …about my ehh… pheno—type… you understand people![Moving towards the learners]*

Mrs. Letsiba LO2,episode 5

The sequences above show how Mrs. Letsiba presented a single specific view about the concepts of co-dominance, phenotype, and genotype based on Mendel's work while she excluded the participation of her learners. At this point, Mrs. Letsiba was doing all the talking, thus it would be wrong to presume that all learners in her classroom accepted the scientific view. This is because learners were not allowed to position the authoritative Discourse of the subject matter concerning their views (Scott et al., 2006). Furthermore, the excerpt shows that Mrs. Letsiba did not offer her learners support for meaningful learning of science concepts in question. It is important to note that in this study there were many instances like the one discussed above from the four teachers' practices. Below is an excerpt from Mr Zindi's interview providing evidence as to why he engages learners in interactive Discourse when teaching.

214. *Mr. Zindi:* *Again, I sometimes do that due to the time factor, where I feel probably there is no time for learner-to-learner interaction.*

Mr. Zindi INT

The finding above concurs with the findings obtained by Mavuru (2019) who found that pre-service teachers engage in a noninteractive/authoritative approach because of limited time. Though this might be advantageous to the teachers, it may compromise the learner's understanding as there would be a lack of support for meaningful learning.

Patterns of Discourse and Teacher Discourse moves

Since the noninteractive/authoritative communicative approach is known for the absence of dialogue, it, therefore, follows that the I-F-E/F and I-R-P-R-P-R-/E chains patterns were not evident in the excerpt above. The noninteractive communicative approach is associated with the providing information move. The excerpt above shows Mrs. Letsiba providing her learners with a scientific view of alleles, phenotypes, and genotypes. As discussed earlier above under the noninteractive/dialogic communicative approach, providing information has lower potential when it comes to supporting learners' reasoning (Ellis et al., 2019). Thus, by employing this move instead of providing learners with alternative views, her learners were provided with less support for conceptual reasoning.

6.10 Summary of key findings about interaction patterns evident during the teaching of basic genetics

Reverting to the research question: ***What forms of interaction patterns are evident during the teaching of basic genetics to grade 12 learners?***

Communicative approaches

The four teachers in this study were interactive in their practice

The four teachers involved their learners in the lessons, although the levels of participation and engagement varied. Only a few learners participated in Mrs. Durand's and Mrs. Letsiba's lessons while a large proportion of learners participated in Mr. Zulu and Mr. Zindi's lessons. It is interesting to note that despite Mrs. Durand's and Mrs. Letsiba's practices being interactive, learner engagement was only superficial. This finding implies, that despite being viewed as beneficial for learner-centred teaching (McMullen, 2014), learner participation does not necessarily mean effective teaching.

Authoritative Discourse was evident in all teachers' practices

All four teachers engaged in authoritative Discourse though Mrs. Letsiba and Mr. Zulu alternated between authoritative and dialogic Discourse in varied ways as they taught their learners the genetic concepts. The alternation between authoritative and dialogic Discourse is consistent with the observation made by Scott et al. (2006). On the one hand, engaging in dialogic Discourse allows learners to open up as they publicise their views. On the other hand, engaging in authoritative Discourse helps the teachers funnel their discussions towards the scientific story. Thus, the shift between the dialogic to authoritative is essential for teaching and learning because meaningful learning entails making links between forms of thinking and talking so that the learners understand how new ideas match with pre-existing ideas (Scott & Ametller, 2007). It was evident from the data that in cases where the teachers engage in both authoritative and dialogic Discourse results in tension between engaging learners' ideas and maintaining the science view (Scott et al., 2006) as seen in one of Mr. Zulu's Lessons where he opened up the Discourse to the learners but quickly closed it up before more learners could publicise their views.

The most prevalent communicative approach was Noninteractive/Authoritative

The preferred communicative approach in this study was non/interactive authoritative, a finding contradicting with Kaya et al. (2016) who found the interactive/authoritative communicative approach to be the most preferred after the call for classes to be learner-centred (McMullen, 2014). The noninteractive/authoritative communication in all four classes was associated with teachers asking questions and then answering them. In some cases, the teachers tried to initiate dialogue, but the learners responded by chorusing answers. In most cases, the noninteractive authoritative alternated with the interactive/authoritative approach which contradicts the observations from Kaya et al. (2016), and Scott et al. (2006) where the interactive/authoritative approach alternated with the interactive/dialogic approach. However, Mr. Zulu and Mrs. Letsiba's classrooms stood out because of the few instances where Mr. Zulu and Mrs. Letsiba alternated between interactive/dialogic and interactive/noninteractive authoritative approaches. This alternation between communicative approaches has been encouraged since it allows learners to engage in dialogic exploration of ideas, and the teacher follows by isolating and clarifying the scientific point of view through the authoritative approach (Aguiar, 2016; Scott & Ametller, 2007).

Patterns of Discourse

The predominant Discourse pattern in all four classrooms was the I-R-P-R-P/E chain (open or closed) with some scenarios of I-R-E/F and I-R_1-R_2-R_3-R_4-P

There was evidence in the four teachers' practices for all the three patterns of Discourse viz, traditional I-R-E/F sequences, I-R-P-R-P open chains and the I-R-P-R-P-E open chains. The predominant Discourse was the open/closed I-R-P-R-P chain pattern which is inconsistent with Lemke (1990); Rees and Roth (2019); Salloum and BouJaoude (2019) who found the predominant Discourse pattern to be I-R-E/F. The extended interaction (open and closed I-R-P-R-P chains) is known for maximising learning by supporting and evoking creative thinking (Rubic, 2017). This finding suggests that the four teachers' classrooms in this study, like others cited in the literature were moving away from the I-R-E/F Discourse, to expanding teachers' follow-up questions which are essential for supporting and making sense of learners' thinking (Lim et al., 2020). A Different form of open chain interaction *I-R_1-R_2-R_3-R_4-P* was identified in Mrs. Letsiba's classroom, where the subscript according to Scott and Ametller (2007) represents a response from a specific learner which is attended to by another learner instead of an evaluation being made by the teacher. This finding provides evidence to show a good aspect of Mrs. Letsiba's teaching since such interactions are known for producing productive Discourse which promotes reasoning ability in learners (Iqbal & Mahmood, 2020) as discussed earlier. Furthermore, open chains have been known for providing scope for greater interactivity and analysis of varying ideas in science classrooms (Scott & Ametller, 2007).

Scott et al. (2006) believe that when used properly, the I-R-E/F pattern has the potential to assist teachers in building a common scientific language. Salloum and BouJaoude (2019) shape learners' ideas, select and share ideas, mark key ideas, check understanding, and review with their learners. Thus, in this study, the I-R-E/F was mostly used in Mrs. Durand's and Mrs. Letsiba's classroom when focusing on genetics terminology or the genetic crosses where learners responded through one-word answers. However, some scholars believe that overuse of the I-R-E/F pattern can be a barrier to learning (Mercer & Dawes, 2014) since it limits learners to talking only when responding to the teacher's questions (Rees & Roth, 2019) hence the need to adopt more extended interaction chains.

Teacher Discourse moves

The following teacher Discourse moves were observed from the four teachers' classrooms

The providing information move

In this study, the noninteractive/authoritative talk which was generally associated with teacher talk or telling Discourse predominantly featured the teacher Discourse move of providing information. This finding is consistent with Carpenter et al. (2020) who found the providing information move to be associated with teacher talk. However, the providing information move also featured in the I-R-E/F Discourse pattern when teachers provided answers to questions initiated by the learners.

Eliciting moves

In I-R-E/F or I-R-P-R-P/E open and closed Discourse patterns are usually initiated by the teacher who raises a question to which a learner responds, and the teacher provides the learner with evaluative follow-up or feedback (Scott & Ametller, 2007). The teachers' questions can either facilitate or constrain classroom interactions. In this study, most classroom interactions were initiated by the eliciting move from the teacher through a closed question with only one possible answer known by the teacher. Nonetheless, there was a slight deviation in Mr. Zulu's, Zindi's and Mrs. Letsiba's (one incident) classrooms, where open questions which encouraged diverse responses from the learners were sometimes used as they attempted to elicit learners' ideas and opinions. In addition, Mr. Zulu and Mr. Zindi made connections (eliciting move) to learners' experiences as well as previous concepts while Mrs. Durand and Mrs. Letsiba only made connections to previous concepts taught. The connection move is known for supporting link-making in learners (Scott et al., 2011) thus enhancing understanding of new concepts. The finding suggests that learners in this study were afforded opportunities for link-making.

Marking moves

Furthermore, to deal with learners' responses all four teachers used the marking moves of repeating learners' responses, revoicing and elaborating on learners' responses. In cases where the interaction pattern chain was extended, the teachers continued to use the eliciting moves of inviting learners to elaborate and explain, eliciting further responses as they dealt with learners' responses, marking learners' ideas as important by repeating and revoicing moves. This finding is consistent with (Windschitl et al., 2020) who found that teachers marked learners' ideas as important while making connections to the science language through repeating and revoicing. Interestingly, the marking move of agree/disagree was only evident in Zindi and Mr. Zulu's classroom. Mr. Zulu said that he used this move to help the learners who were struggling with the content in question.

Building moves

Unfortunately, the building moves were rarely used in this study, yet they are high-ranking and are known for offering support for conceptual reasoning (Carpenter et al., 2020). In this study, the building move of reasoning was only used by Mr. Zulu and Mr. Zindi. This finding suggests that learners in this study had fewer opportunities to elaborate on their reasoning.

Evaluation moves

At the end of the interactions, three teachers in some instances offered learners motivation or put-downs before or after feedback. However, the type of motivation offered in this study has been criticised since it is not linked to the substantive content in question (Scott et al., 2011).

Overall, the most productive Discourse occurred in dialogic interactions which were associated with extended interactions through long closed or open chains. These open chains were enhanced by building moves where the teachers asked learners open-ended questions requiring reasoning clarification and justification. This type of Discourse is productive because it provides learners with opportunities to learn.

6.11 Chapter Summary

In this chapter, I presented findings for the four teachers who participated in this study based on my second sub-research question; ***What forms of interaction patterns and teacher Discourse moves are evident during the teaching of basic genetics to grade 12 learners?*** Based on literature the most productive Discourse is characterised by dialogic interactions which allow for meaningful/deep learner participation and exploration of their ideas and perspectives (Iqbal & Mahmood, 2020; Scott et al., 2011). Such Discourse is known for offering support in terms of knowledge building, learner interest and conceptual reasoning as it links science and everyday views. The predominant approach evident in the four classrooms is noninteractive authoritative where learners were engaged in the interactions in a superficial way though there were very few instances where (two teachers attempted to get deeper). Dialogic interactions are known for the exploration of learners' ideas and perspectives (Scott et al., 2011). In this study, there was very little exploration of learners' ideas since the teachers generally adopted the interactive authoritative communicative approach. An interesting example of dialogic interactions unfolded in Mr. Zulu's classroom where he invited learners' opinions but quickly shut down the Discourse by introducing the scientific view. This finding suggests that the tension that exists between dialogic and authoritative Discourse (Scott et al., 2006) prevents interactions from developing into productive Discourse.

Productive Discourse is usually associated with extended chain patterns which have the potential to support learner conceptual reasoning (Ellis et al., 2019; Howe & Abedin, 2013). In addition, these chains have the potential to provide a scope for greater interactivity and analysis of varying ideas (Scott & Ametller, 2007). In terms of productive Discourse, the extended chains are associated with building moves (reasoning and clarification) which have the potential to support learner conceptual reasoning and push learners' thinking further (Ellis et al., 2019; Howe et al., 2019). Furthermore, it is associated with the connection move which has the potential to support knowledge-building through linking science and everyday views. Generally, this study was associated with extended chains though the engagement of learners was superficial in Mrs. Durand and Mrs. Letsiba's classroom as noted earlier. This finding suggests that though the classes were highly interactive, the Discourse was generally not productive in these two classrooms. Building moves was only employed by two teachers (Mr. Zulu and Mr. Zindi while the connection move was used by all teachers.

Consequently, dialogic interactions associated with extended chains of interactions where probes were non-evaluative, building moves and connecting moves were the most productive forms as they were linked to the conceptual teaching of genetics concepts. In the next chapter, I present findings for the four teachers based on my third sub-research question; ***What kinds of emergent teacher strategies can be extracted from the Discourse of teaching basic genetics to grade 12 learners?***

CHAPTER 7: DISCOURSE STRATEGIES EXTRACTED FROM THE TEACHING OF BASIC GENETICS

7.0 Introduction

In Chapter 5, I demonstrated the patterns of interaction that were evident in terms of the communicative approach, patterns of Discourse, and teacher Discourse moves. In particular, I focused on how teachers directed the science talk during the teaching of genetics concepts using one or more communicative approaches through a variety of teacher Discourse moves. In Chapter 6, I illustrated, through Thematics, how teachers developed genetics concepts during the teaching of basic genetics to grade 12 learners. I did this by focusing on the Thematic items used, how they were used to build semantic relations and subsequently the construction of Thematic patterns. The next step is to answer the following questions proposed by Lemke (1990). How, in a classroom, do teachers and learners use language to build up Thematic patterns that correspond to the conceptual systems of a subject like science? What strategies are used to make it easier for learners to correctly infer semantic relationships from the words that are actually heard? How, in short, can we teach Thematic patterns in the classroom as we use them? Lemke refers to these strategies by which teachers and learners come to share a new Thematic pattern in their classroom dialogue as Thematic development strategies. These are used in concert with social interaction strategies and multimodal representations. In this study, I refer to all these strategies as Discourse strategies as discussed in Chapter 2.

In this chapter, I present results and major findings for the four participant teachers in terms of the third sub-research question, "***What kinds of emergent teacher strategies can be extracted from the Discourse of teaching basic genetics to grade 12 learners?***" I sought to understand the Discourse strategies that the teachers used to negotiate meaning-making with their learners. In this study, the word 'strategy' is not the traditional understanding of the word 'strategy' but is adopted and used the same way as Lemke (1990) did in his seminal work 'Talking Science'. It is used to describe the techniques engaged by teachers during the development of Thematics during the teaching of basic genetics. Analysis of the teachers' practices explored emergent teacher Discourse strategies extracted from the Discourse of teaching basic genetics to grade 12 learners. Teacher Discourse strategies were analysed in terms of the following three aspects presented in the theoretical framework (Figure 2.3) in Chapter 2.

- Thematic development strategies

- Social interaction strategies
- Multimodal representations

7.1 Data sources for this chapter

In this study, the main sources of data were the twelve lesson observation transcriptions which were generated from video recordings of a series of three consecutive lessons taught by four different teachers to grade 12 learners during the teaching of basic genetics. These lesson observations were transcribed in detail to capture the visual details of gestures, physical movements of teachers and learners, chalkboard work, and practical demonstrations. To augment the data captured by the videos, other sources of data viz, post-lesson observation interviews and field notes were used for data triangulation purposes. This additional data helped me to access teachers' rationale for taking certain actions during the observed lessons. Moreover, the interviews provided more information for answering the above sub-research question and enhanced the trustworthiness of my analysis as the various data collection methods complemented each other.

7.2 Method of Analysis

As discussed earlier in Chapter 4, the main sources of data were obtained from lesson observation transcriptions which were transcribed in detail to capture contextual features like gestures. Analysis for this chapter was influenced by Lemke's thematic analysis discussed in Chapter 4. As a reminder, Lemke (1990), describes 'Discourse strategies' as specific techniques used by teachers to build up a network of semantic relations (thematic pattern) existing among the crucial terms of a subject referred to as thematic items. To analyse data for this chapter, as discussed in Chapter 4.6.1, I started by identifying the 'Discourse Episodes' for all teachers. I then identified the teacher Discourse strategies, which included monologue and dialogue, social interaction strategies as well as multimodal representations. These Discourse strategies are presented in Table 7.1 to provide a structure of the strategies that will be presented in the proceeding sections.

Table 7. 1: Structure of the strategies, and their categories

Category	Sub-category	Strategies
Thematic Development strategies	Monologue	Logical exposition, narrative, selective summary
	Dialogue	Teacher question series, external text dialogue, learner-teacher duolog, cross-discussion, learner challenge
Structural interaction strategies	Structural control	Controlling pacing, admonition sequences, interrupting learners
	Thematic control	Signalling boundaries, marking importance, marking new/old information
Multimodal representations	Visual	Images, pictures, role play
	verbal	Extra stress, dragging words, high/low pitch (voice modulations)
	Gesture	Use of hands/body, movement

7.3 Distribution of thematic, social interaction strategies and multimodal representations in the four teachers' lessons

Table 7.2 shows the thematic development strategies, social interaction strategies and multimodal representations (Lemke, 1990), that were evident in the twelve lessons observed when the teachers were dealing with the specific genetics concepts listed. It is evident from Table 7.2 that Mrs. Durand, Mr. Zindi and Mr. Zulu initially focused on the same concepts viz, structure of chromosomes, cell division, and cell cycle including the process of mitosis. To be specific, these concepts were covered in their first set of observations (LO1) where they developed the scientific story of mitosis by linking the structure of chromosomes to cell division as well as the cell cycle including the process of mitosis. During this process, these teachers constructed semantic relations among genetics terms[10] using monologue strategies (**selective summary**, **fore/backgrounding**) and dialogue strategies (**teacher question series**). The monologue and dialogue strategies were used in tandem with social interaction strategies and multimodal representations. Mrs Durand, Mr. Zindi and Mr. Zulu engaged in monologue and dialogue strategies to assist learners in inferring the semantic relations and thus, thematic patterns (Lemke, 1990) constructed as the teachers linked the genetic terms[1]. Social interaction strategies were used to emphasise important points made by the teachers as they constructed

[10] Chromosomes, centromere, chromatids, chromatin network, cells, somatic cells, nucleus, nuclear membrane, mitosis, cell cycle, haploid, diploid, spindle fibres, centriole, interphase, prophase, metaphase, anaphase, telophase, cytokinesis, DNA Replication

semantic relations between genetics terms[1] while multimodal representations were fused to assist learners in understanding abstract natural phenomena (mitosis, chromosome) that may not be crystal clear from each representation (Won et al., 2014). Mrs. Letsiba's Lesson Observation 1 was different from the other teachers as shown in Table 7.2 by the first set of concepts covered (structure of chromosomes, process of meiosis, abnormal meiosis, and consequences). She was initially observed developing the scientific story of meiosis since she was ahead of the other teachers. To do so, she engaged in monologue and dialogue strategies to connect the structure of chromosomes to the processes of meiosis and abnormal meiosis as well as consequences. It is important to note that Mrs. Letsiba's practice stood out in the sense that she engaged her learners in cross-discussion. Though she used it once, Mrs. Letsiba tried to allow her learners to construct semantic relations and thematic patterns (refer to Chapter 5) thus, practising talking science (Lemke, 1990) on their own.

Further, Table 7.2 shows on the one hand, that Mrs. Durand and Mr. Zindi dealt with the same concepts (inheritance and monohybrid crosses) at some point during their observed lessons. This may imply that they constructed the same semantic relations among certain genetics terminology[11] and thematic patterns. On the other hand, Mrs. Letsiba and Mr. Zulu besides dealing with the concepts of inheritance and monohybrid crosses in their lessons, also dealt with sex determination, sex-linked inheritance and genetic lineages. These two teachers managed to cover more concepts than others because theirs were double lessons. All four teachers introduced the concept of inheritance using a **narrative** of Gregor Mendel's life and his work. This was done in tandem with multimodal representations such as pictures of the plants that Mendel used, symbols and notes either on the board or slides and social interaction representation when introducing Mendelian genetics.

Overall, the predominant thematic development strategy was a monologue, where the teachers used **foregrounding and backgrounding**, **narrative**, or **selective summary** methods. The most common dialogue method was the **teacher question series** while methods such as **teacher-learner duolog**, **learner questioning**, **cross-discussion**, **learner challenge** and

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[11] Monohybrid, genetic cross, P_1 (First parental generation), P_2 (second parental generation), phenotype, genotype, meiosis, gametes, sex cells, ova, sperm cells, alleles genes, segregation, fertilization, offspring, F_1 (first filial generation), F_2 (second filial generation), heterozygous, homozygous, dominant allele, recessive allele

classwork were rarely used in this study. The finding about **learner questioning** is consistent with research which shows that teachers make very little use of the potential of learner questioning (Stokhof et al., 2017). These thematic development strategies were used in conjunction with social interaction strategies as well as multimodal representations. The use of two or more representations when teaching a concept is considered as teaching with multimodal representations (Opfermann et al., 2017).

As they taught genetics concepts using monologue or dialogue strategies in either authoritative or dialogic Discourse, all teachers signalled boundaries, controlled pacing, marked importance and old information while they incorporated multimodal representations such as stress, high pitch, hand gestures, images, symbols, and notes. **Getting personal** and **being funny**, though not evident in all lessons, were used in this study. It is interesting to note that Mrs. Letsiba's practice stood out in this case in the sense that in her monologue strategies, besides the **gestures** and **verbal representations** used by other teachers, she included song and role play as she tried to build semantic relations. Role play is seen as one of the most inspiring and powerful strategies that can improve learners' comprehension of science concepts (Abed, 2016). Thus, the inclusion of role play in Mrs. Letsiba's practice suggests that she created an environment that had the potential to inspire learners and provide opportunities to improve their understanding of science concepts. In the next section, I present the thematic development strategies.

Table 7. 2: Summary of distribution of thematic development, social interaction strategies and multimodal representations per teacher

Teacher	Genetics concepts covered	Thematic development strategies	Social interaction strategies	Multiple representations
Mrs. Durand	Structure of chromosomes, cell division mitosis, process of mitosis, importance of mitosis, difference in telophase between plant and animal cells, inheritance, monohybrid cross	**Monologue** Selective summary, fore/backgrounding, narrative, logical exposition **Dialogue** Teacher Question series, Learner Question, learner-teacher duolog, external text dialogue	Thematic control, structural control (getting personal)	Verbal, visual, gestures
Mrs. Letsiba	Structure of a chromosome, process of meiosis, Abnormal meiosis, and consequences, , Inheritance, Monohybrid crosses, sex determination, sex-linked inheritance	**Monologue** Selective summary, narrative fore/backgrounding, logical exposition **Dialogue** Teacher question series, Cross-Dialogue, Learner-Teacher Duolog, external text dialogue	Thematic control, structural control (being funny, getting personal)	Verbal (song), visual (role play), gestures
Mr. Zindi	Structure of chromosomes, cell division mitosis, the cell cycle including process of mitosis, difference in telophase between plant and animal cells, Inheritance, Monohybrid crosses	**Monologue** Selective summary, narrative, logical exposition, fore/backgrounding **Dialogue** Teacher question series, external text dialogue	Thematic control, structural control (being funny, getting personal)	Verbal, visual, gestures
Mr. Zulu	Structure of chromosomes, cell division mitosis, the cell cycle including process of mitosis, difference in telophase between plant and animal cells, Concepts of inheritance, Monohybrid crosses, sex determination, sex-linked inheritance, Dihybrid crosses, Genetic lineages/pedigree diagrams	**Monologue** Selective summary, narrative, logical exposition, fore/backgrounding **Dialogue** Teacher question series, external text dialogue, learner-teacher duolog, learner challenge	Thematic control, structural control (getting personal)	Verbal, visual, gestures

Refer to Appendix G for a more detailed table

7.4 Thematic Development Strategies

Thematic development strategies are the specific tactics that are employed by teachers to build semantic relations during the teaching of genetics concepts (Tang, 2020). This study uncovered two strategies which are dialogue and monologue as shown in Figure 7.1.

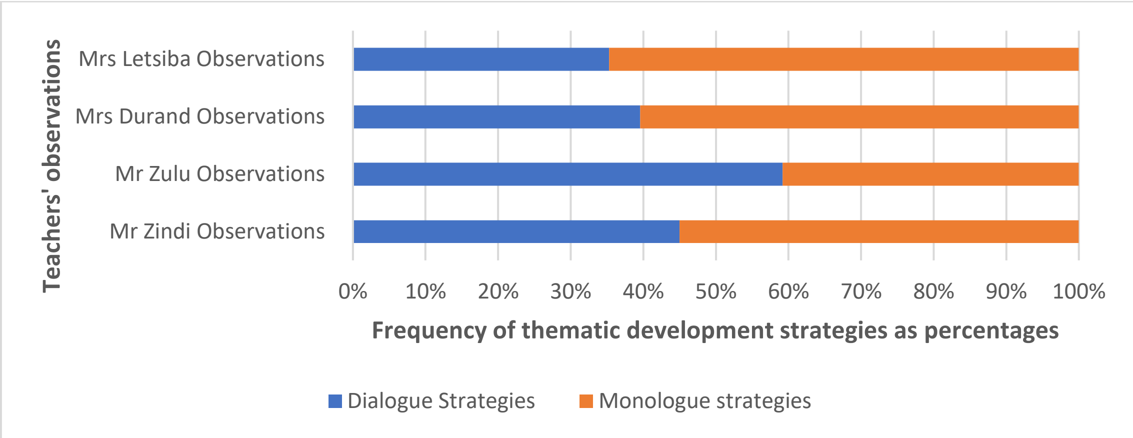

Figure 7. 1: Types of thematic development strategies per teacher as a percentage

Figure 7.1 shows that all four teachers used monologue and dialogue thematic development strategies though their practices were characterised more by monologue strategies than dialogue strategies except for Mr. Zulu's practice which had more dialogue strategies. In fact, 59% of Mr. Zulu's practice was characterised by dialogue strategies while less than 50% of the other three teachers' practices were characterised by dialogue strategies. Dialogue assists students to build understanding, improve critical thinking and test new thinking thus learners need more opportunities to speak so that they can practice using the language of science (Dobber & van Oers, 2015). In addition, dialogue strategies are considered tools that allow learners to take their thinking to greater levels, improving their knowledge as they strive to discover new understandings and develop greater insights (Mercer & Dawes, 2014). Hence, through dialogue strategies, Mr. Zulu enabled his learners to develop the skills required to interact and establish collective thinking with their colleagues as highlighted (Mercer, 2016). During his interview, Mr. Zulu provided the following as the reasoning for involving his learners in dialogue.

124.	*R:*	*Okay so, what do you expect from your learners when they are in your classroom during your lessons?*
125.	*Mr Zulu:*	*Ehh…I expect them to cooperate ehh…I expect them to also participate in our lesson.*
126.		*You know I do not want to keep on teaching as if maybe it is ehh…I am preaching or a lecture mode of teaching.*
127.		*So, I just want them to be part of the lesson.*
128.		*That is why I try by all means to keep on asking them questions, so that they can be engaged.*
129.		*So, I just expect them to be part of the lesson.*

Mr. Zulu INT

The excerpt above shows that Mr. Zulu strongly expressed the view about his interest in learner participation and the need for him to refrain from using the lecture method throughout the lessons in a way that was reflected in his practice. In the next section, I discuss the findings of these two strategies (monologue and dialogue) in detail.

7.4.1 Dialogue Strategies

This study unveiled four dialogue strategies that were used by teachers when building semantic relations and thematic patterns. These strategies are **cross-discussion**, **external text dialogue**, **teacher-learner duolog**, **teacher question series, learner question and learner challenges** occurring in a triadic dialogue. According to Tang (2020), **Cross-discussion** is a pattern of dialogue where learners are allowed to speak about the subject matter in question directly to each other while the teacher assumes a moderator role. **External text dialogue** occurs when the teacher's question, notes, or learner's answer is read from a written text where the written text is assigned a 'participant role in the dialogue. **Teacher-learner duolog** is characterised by a series of extended exchanges between the teacher and one learner. Lastly, when it comes to **teacher question series**, Tang (2020) further argues that the teacher asks learners a series of closely related questions in a triadic dialogue as they construct semantic relations. **Learner questioning** is considered to support knowledge construction since asking questions is an integral part of exploring information requiring the learner to make an effort to identify gaps in their prior knowledge (Pardo & Bakes, 2015). Besides, **learner questioning** is considered to be a potential tool for teaching learners to exercise self-regulated learning (Stokhof et al., 2017).

In this study, dialogue refers to exchanges/interactions taking place between teacher and learner/s about the subject matter in question. Any interaction/exchanges between teacher and learner/s that are not concerned with the subject matter were not regarded as dialogue. Figure 7.2 below shows the types of dialogue strategies used by each teacher in this study and their frequencies.

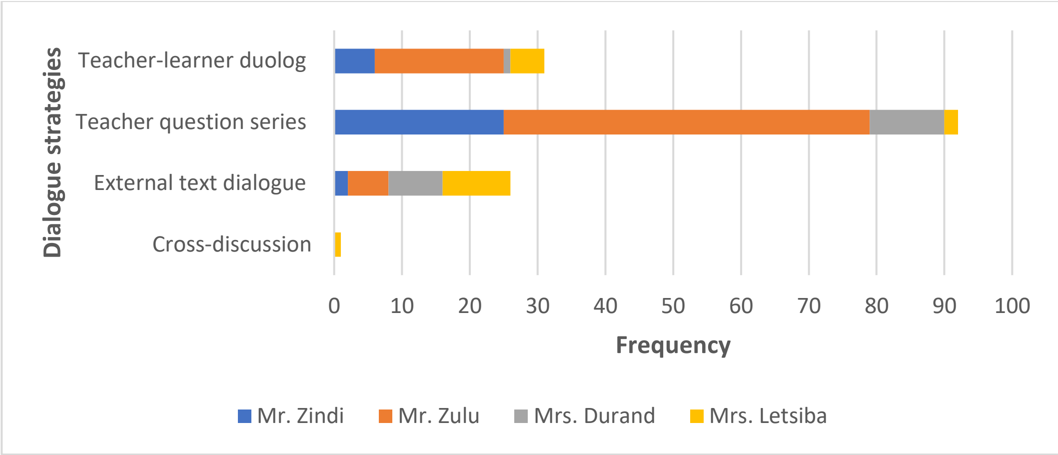

Figure 7. 2: Dialogue thematic development strategies and their frequencies per teacher

It is evident in Figure 7.2 that the most common dialogue strategy was the **teacher question series**. This is similar to the findings obtained by Bickmore (2014); Hennessy et al. (2023); Lin and Lo (2017) and Axelsson and Jakobson (2020) who found the **teacher question series** strategy to be the most popular strategy. In some cases, the strategy **teacher question series** was used in concert with **external text dialogue**. In this study, as shown in Figure 7.2, **external text dialogue** was the third most predominant dialogue strategy used by all four teachers. **External text dialogue** is a form of dialogue where a written text or quoted text is assigned a 'participant role' or substitutes the actual participant's voice (Lemke, 1990).

The sequences below provide an example of a scenario where a teacher question series was used in tandem with external text dialogue. The sequences were extracted from an episode where Mr. Zulu was engaged in the conceptual development of Mendelian genetics with his learners through a **teacher question series** as he drew from the course textbook (**external text dialogue**) for questions. This scenario occurred when the teacher was going over classwork (seatwork) on genetic problems and associated terminology[12] in a dialogue. This practice of building concepts while going over classwork was only evident in Mr Zulu's and Mr. Zindi's classrooms which made their practices stand out. Seatwork (classwork) is an activity where learners work independently on a specified task in their seats (Lemke, 1990).

Mr. Zulu LO3: Revising genetic problems and lineages

706.	*Mr. Zulu*	*Right now, let us look at the questions.* *Number one or a) it says, [reading] "are the grandparents of the third generation heterozygous or homozygous" ...Sello!*

[12] Albinism, dominant, dominant A, recessive a, genotypes, phenotype, alleles, offspring, homozygous, recessive alleles and dominant alleles.

707.	*Sello:*	*Heterozygous!*
708.	*Mr. Zulu:*	*Heterozygous, do you agree?*
709.	*Ls:*	*Yes!*
710.	*Mr. Zulu:*	*Right third generation.*
711.		*This is the third generation [showing] …and these will be their parents…and the grandparents.*
712.		*Right so, you can all see this is homozygous… this is also heterozygous*
713.		*So, the grandparents are heterozygous.*
714.		*Let us move to [reading] "b); …explain your answer in a) " Moore!*
715.	*Moore:*	*Because the alleles are not the same.*
716.	*Mr. Zulu:*	*The alleles are not the same ahh…no!*
717.		*That is not how you should explain that.*
718.		*Remember we are tracing…this allele for albinism.*
719.		*It means that both parents are heterozygous. Yes! [Pointing to a learner]*
720.	*Thabani:*	*I think because both parents are carriers.*
721.	*Mr. Zulu:*	*Both parents are carriers…okay it is partially correct. Yes*
721.	*Sinenhlanhla:*	*Because of the three children one has albinism.*
722.	*Mr. Zulu:*	*Ehm.*
723.	*Sinenhlanhla:*	*Because out of the three children, one has albinism.*
724.	*Mr. Zulu:*	*One has albinism remember; you are explaining that heterozygous situation of the grandparents.*
725.	*Sinenhlanhla:*	*Yes!*
726.	*Mr. Zulu:*	*Okay because they had…*
727.	*Sinenhlanhla:*	*Because they had offspring that had albinism it means that both parents are hetero… heterozygous.*
728.	*Mr. Zulu:*	*Okay, we are looking at this generation… …okay and we are saying that for this generation to have albinism, the parents must be heterozygous…*
729.	*Sinenhlanhla:*	*After the grandparents!*
730.	*Mr. Zulu*	*…and the grandparents must be heterozygous, okay I will take that one. Yes! [Referring to a learner]*

Mr. Zulu LO3 episode 7

The scenario above occurred in an episode that started as monologue and evolved into various forms of dialogue viz, **teacher question series**, **teacher-learner duolog** and **external text dialogue**. Generally, Mr. Zulu was building the concept of genetic lineages while linking it to autosomal recessive inheritance and monohybrid crosses. Overall, to accomplish this, Mr. Zulu used **teacher question series** while drawing on external authority using **external text dialogue** (turns 706, 714) to ask learners questions, and engaging Sinenhlanhla in a duolog (turns 721-730). In particular, the extract above shows Mr. Zulu developing the concept of solving genetic problems using an example of albinism and a pedigree/lineage diagram. He inductively helped his learners to form a clear understanding of the concept by studying an example of the concept. Such type of engagement with learners assists them to form concepts from examples resulting in them knowing more than definitions of terms. There were similar instances in Mr. Zindi's classroom. Thus, Mr. Zulu and Mr Zindi created environments that had the potential to enhance deep conceptual learning rather than a superficial knowledge of genetics terminology. Though Mrs. Durand and Mrs. Letsiba also engaged their learners in **teacher-learner duolog**, Mr.

Zulu's classroom stood out in this respect because he engaged Sinenhlanhla more by using the building moves (refer to Chapter 6) which elicited learners' reasoning or justification of their responses (Carpenter et al., 2020) in turns 721,723 and 727. As discussed in Chapter 6, building moves are known for their high potential for supporting learners' reasoning (Ellis et al., 2019; Howe et al., 2019). Hence, Mr. Zulu afforded his learners more support for reasoning. Overall, the excerpt above provides evidence to show that Mr. Zulu was conceptual development-focused during his teaching.

An example of **cross-discussion** unfolded in Mrs. Letsiba's Lesson Observation 1, episode 1 when she was recapping on meiosis before introducing abnormal meiosis.

Mrs. Letsiba LO1: Abnormal meiosis

146.	*Kamogelo:*	*Ehh…ma'am how are these spindle fibres formed? [Using hands]*
147.	*Takudzwa:*	*It is when the centrosome split into two centrioles ehh… they go in opposite poles…and then they form-- the centrioles form the spindle-- the spindle. [Smiling]*
148.	*Ls:*	*[Applause]*
149.	*Mrs. Letsiba:*	*…and then another one…*
150.	*Kamogelo:*	*Ma'am I am not done!*
151.	*Mrs. Letsiba:*	*You do not have to be is that not so?*
152.	*Chinasa*	*Madam, I want to correct / ? / when we go to metaphase 1 the chromosomes are attached to the spindle fibres*
153.	*Jeremy:*	*But in metaphase 1 that is when the spindle fibres are formed.*
154.	*Chinasa:*	*EVEN IN METAPHASE 1… …chromosomes are attached to the spindle fibres.*
155.	*Jeremy:*	*/ ? /*
156.	*Mrs. Letsiba:*	*Thank you! [Points to Takudzwa]*

Mrs. Letsiba LO1, episode 1

The excerpt above shows how learners spoke directly to one another about meiosis the subject matter in question while the teacher assumed the role of moderator. According to Lemke (1990), **cross-discussion** is a type of dialogue that is of higher status than triadic dialogue. Thus, Mrs. Letsiba is the only teacher in this study who tried to engage her learners in this high-status dialogue. Nonetheless, it is interesting to note that this was the only instance of **cross-discussion** in Mrs. Letsiba's classroom and this study in general. For Mrs. Letsiba, this is the only instance that she tried to engage her learners in conceptual development. This incident provides evidence that Mrs. Letsiba tried to make her lessons learner-centred, an approach advocated for in the current education debates (McMullen, 2014).

7.4.2 Monologue Strategies

Monologue strategies unfold in a science classroom when teachers provide information, expound a point, narrate a story, provide a long answer to a learner question, or sum up a discussion (Lemke 1990). This study unveiled four monologue strategies that were used by teachers when building semantic relations and thematic patterns. These are **logical exposition**, **selective summary**, and **narrative**, as well as **foregrounding and backgrounding**. **Logical exposition** occurs when teachers undertake to make a sensible argument by connecting various thematic items as well as semantic relations and these connections cannot be done effectively using triadic dialogue (Lemke, 1990). With **selective summary**, the teacher summarises previous Discourse by selecting certain thematic items and semantic relations (Lemke, 1990). Since **selective summary** includes only the essential items and semantic relations, it helps students to not know what is important in the end and what is not. Teachers use the **narrative** strategy to give an account of events or actions in chronological order and are aimed at getting to a climax or end result as well as explaining complex processes that occur in stages (Lemke, 1990). Lastly, **foregrounding and backgrounding** occur when the teacher repeats prior Discourse while marking certain themes as of greater importance and others implicitly as of lesser importance (Lemke, 1990). This strategy takes selection to a higher level by marking some thematic elements and semantic relations as more important than others. The monologue strategies discussed above are shown in Figure 7.3 per lesson for each teacher. In this study, a monologue refers to six lines of a teacher's continuous talk.

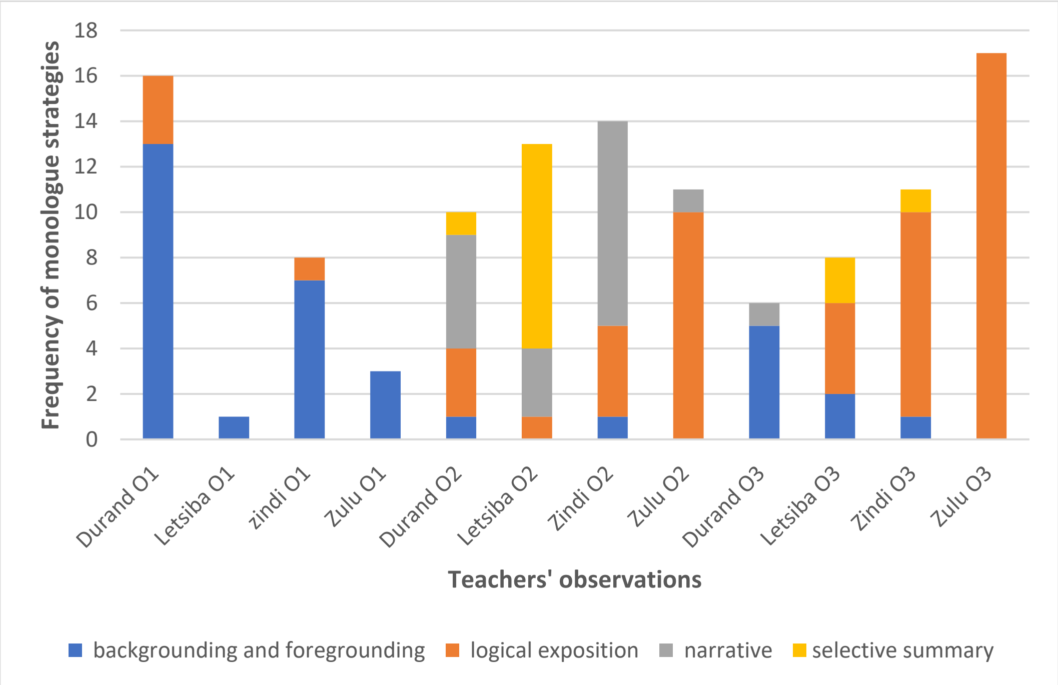

Figure 7. 3: Monologue thematic development strategies and their frequencies per teacher

Figure 7.3 shows that during the first series of lesson observations (O1) where the teachers were focusing on meiosis, the predominant type of monologue thematic development strategy was **foregrounding and foregrounding**. According to Hochstein (2022), foregrounding and its complement backgrounding perform the function of selecting and synthesising the most important thematic items and relations. It does so by highlighting within the summary the actual concepts that are essential. Thus, in this study **foregrounding** was done in summaries through vocal emphasis (e.g., verbal stress) on the important terms associated with the concept of meiosis. On the one hand, the teachers highlighted and expressed the foregrounded terms that were going to be pivotal to the proceeding topic of genetics. On the other hand, the terms that were of less interest when it came to the genetics topic were relatively backgrounded. For instance, during her Lesson Observation 1, Mrs. Durand backgrounded the concept of the cell cycle (G1-gap 1 phase, G2- gap 2 phase, M- multiplication phase and S-synthesis phase) despite referring to it. She probably did this because the information does not directly impact the topic of 'genetics'. Thus, in this study **foregrounding and backgrounding** were used to accurately identify the concepts of future interest and to distinguish them from others that could complicate their learners' understanding of the proceeding topic thus, preparing learners for the proceeding topic (Tang, 2017) genetics.

The sequences below provide an example of a scenario where **foregrounding and backgrounding** were evident. These were extracted from episode 14 of Mrs. Durand's Lesson Observation 1 where she focused on meiosis terminology[13].

Mrs. Durand LO1 (LO1- Lesson Observation 1): Meiosis

204.	*Mrs.Durand:*	*Okay, our terminology that we are going to use-- is first— I am going to write them in order.*
205.		*Diploid which I already mentioned [pauses as she writes on the board]okay, so this is meiosis terminology [writing on the board]. [Learners copying terms into their workbook]*
206.		*There is still a person mumbling and you are irritating me [stops writing and looks at the learners].*
207.		*Okay, [writing on the board] we can call these two sets of chromosomes in a cell [pauses] [learner coughs] and we refer to this as 2n, double the number.*
208.		*Then we are going to have haploid [pauses as she writes on the board] okay, we going to refer to this as just n.*
209.		*In other words, HALF the number of chromosomes.*
210.		*We also going to look at again somatic CELLS [pauses as she writes on the board] ↑all cells of the body EXCEPT for the sex cells.*
211.		*Okay [writing on the board] …there is one, two three terms already. [Looks into her book]*
212.		*I am going to continue on this side. [Erasing the board]*

[13] Mitosis, meiosis, chromosomes, diploid, n, 2n, cells, autosomes, sex gamete, sex cell, sperm, ova, sex chromosomes, gonosomes, XY, XX, chiasma, organism, testis, organs, and ovaries

213. I am going to use the term autosomes. [Writing it on the board]
214. [Holding her notebook and reading] "It is a chromosome that does not determine the sex of an individual".
215. I am going to come back to why I am saying that okay, [pauses as she writes on the board].
216. Then we are going to have gamete [pauses as she writes on the board][Looks into her notebook] THAT IS A "SEX CELL" GUYS, it is either a sperm or an ovum, ovum singular, ova plural alright singular here okay and ova plural.
217. Then we have gonosomes, these are the "SEX chromosomes of an individual"...
218. That is either a X or a Y okay, male XY-- will be female XX, male XY [writing that on the board].

Mrs. Durand LO1, episode 14

After focusing on the concept of 'mitosis', Mrs Durand in an extended monologue in episode 14, **foregrounded** the science terms and meanings constructed so far that were going to be pivotal to the proceeding concept that she was going to deal with which is 'meiosis'. Thus, she emphasised the pivotal terms while relatively backgrounding those terms and meanings that were of less interest when it comes to meiosis were relatively **backgrounded. Foregrounding and backgrounding** are important for learners because as the lesson progresses, they normally do not have an idea of what will turn out to be critical or not at the end (Tang, 2017). There were multiple instances in this study where all four teachers **foregrounded and backgrounded** terms and meanings. Hence, this strategy emphasises the most important terms and their meanings in preparation for the proceeding topics. Besides foregrounding and backgrounding, teachers in this study also made selective summaries as the introduced and concluded lessons. Like foregrounding and backgrounding, a **selective summary** of the terms and meanings constructed already plays a pivotal role in pointing learners to the most important terms and meanings of the day (Axelsson & Jakobson, 2020). These findings suggest that all four teachers in this study afforded their learners opportunities to identify the important terms and meanings that were pivotal to the current and proceeding topics. However, **foregrounding and backgrounding** were more by Mrs. Durand and Mrs. Letsiba whose interest was covering the curriculum for learners to get marks rather than developing concepts in their learners).

Figure 7.3 shows that the use of the **narrative** became predominant in the second series of observations, where the teachers were introducing the topic of 'genetics'. This was the case because now the teachers were introducing 'genetics' using Gregor Mendel's life history and work. So, the teachers had to present Mendel's life and work as a **narrative** in chronological order aiming at getting to the climax (Lemke, 1990) which was becoming the 'Father of genetics'. Science stories can be used as effective vehicles to "convey" content that is necessary for teachers and learners to describe, reason and construct explanations that are robust in a more coherent way around science issues (Revel Chion & Adúriz-Bravo, 2022). Hence, through a narrative, the teachers in this study, created an environment that had the potential to help learners to develop skill for reasoning, describing, and constructing robust explanations about science issues. A common pattern that unfolded in this study where the teachers gave an account of Gregor Mendel's life and work that led to the discovery of genetics resulting in him being called the father of genetics.

Furthermore, Figure 7.3 shows that the **logical exposition** strategy began to appear and became dominant in the final series of the observed lessons. Here, the teachers were now focusing on Mendelian genetics where they were presenting genetic crosses. The teachers in this study taught the concept of genetic crosses in two different ways. Mrs. Durand and Mrs. Letsiba taught this concept procedurally while Mr. Zulu and Mr. Zindi taught this conceptually, examples of these two ways follow.

Example 1: Procedural development.

The sequences below provide an example of an episode where the teacher dealt with the concept of genetic cross procedurally. The excerpt below was extracted from episode 8 of Lesson Observation 2 where Mrs. Durand was teaching procedurally genetic crosses.

Mrs. Durand LO2: Genetic problems

224.	*Mrs. Durand:*	*So, whenever we write out the genetics problem, we are going to start.*
227.		*I will show you; we are always going to put a 'P' down and with this 'P' depending on where we are in our crosses, it can either be 1 or 2 but what we are going to do now, we are going to call parent 1…our first set of parents right…here we are going to first look at; what do the parents look like?*
228.		*Geno…phenotype okay remember that okay… [writing]*
229.		*We are going to have a sentence, or something written down.*
230.		*In this case I can say, true white crossed with true purple.*
231.		*If I use Mendel's experiments, okay this is my example okay you understand it?*
232.		*Now we are going to say; what is it the genetic make-up of these parents?*
233.		*Here we are going to put in genotypes.*
234.		*Okay, I am just going to put stuff down, do not worry because we will work out the cross eventually okay.*
235.		*So, we are going to say okay …this is going to be a thing to remember.*
236.		*You always use the same symbols…for whatever characteristic you look at in this section of your work.*
237.		*So, we are going to say our white crossed with purple, but we do not know anything yet.*

238.		*So, for now just say; okay let us just say a white and a purple and we are just going to put a W and a W, a P and a P… those are the genes.*
239.		*Now we are going to say; if these are the genes what happens in the sperm, what will happen in the ovum?*
240.		*To form a sperm what is going to happen?*
241.		*What is going to happen? [Stares at learners]*
242.		*We are going to have meiosis taking place… …and what is meiosis going to give us?*
243.		*Now! What is the word for sperm and ovum?*
244.	*Ls:*	*[Noise]*
245.	*Mrs. Durand:*	*Now that is a nice word.*
246.	*Mpilo:*	*Gamete!*
247.	*Mrs. Durand:*	*Gametes…there you go!*
248.		*Now ↑to make it easy to remember okay you will draw this.*
249.		*Every time you do a genetic cross, you are going to draw a sperm okay and an ovum. [Drawing]*

Mrs. Durand LO2, episode 8

The episode above shows how Mrs Durand engaged the **logical exposition** strategy in a monologue. It shows how the teacher procedurally connected the genetics terminology as she exposed her learners to the 'genetic cross' which was new to them. So, Mrs. Durand taught her learners the concept of genetic cross deductively that is from rule to example unlike Mr. Zulu who taught the same concept inductively (example to rule). The excerpt above shows how Mrs. Durand demonstrated the format on the board from either P_1 or P_2 in (turn 227) to presenting the phenotypes (turns 228-230) and genotypes (turn 232). In trying to make a logical argument, Mrs. Durand asked her learners questions such as "*What do the parents look like?" "What is it the genetic make-up of these parents?"* (turns 227, 232) which seemed to have no responses from the learners. A closer look at the way Mrs. Durand asked these questions, proceeded with her argument and eventually responded to them shows that they were rhetorical questions. These questions were asked not as a genuine inquiry but instead to make connections between parental phenotypes and genotypes. In addition, Mrs. Durand could have used rhetorical questions to activate and persuade her learners smoothly and indirectly to pay attention to the discussion (Moshavi, 2015) at hand. There were multiple instances where all four teachers used rhetorical questions in monologues. On the one hand, when used judiciously and effectively, rhetorical questions can be a potent way of engaging learners, and ultimately, guide them to view the case from one's perspective (Gultom, 2021). On the other hand, other hand Gultom (2021) further argues that rhetorical questions need to be used sparingly otherwise the learners may find them distracting and counterproductive which is evidenced by the learners' noise in turn 244. This noise erupted after Mrs. Durand asked the following questions consecutively; "*… what will happen in the ovum?", "To form a sperm what is going to happen?", "What is going to happen?", "We are going to have meiosis taking place, and what is meiosis going to* *give us?", "Now! What is the word for sperm and ovum?"* (turns 239, 240, 241, 242, 243). The noise could be indicative of the distraction and confusion that Mrs. Durand's rhetorical questions could have caused to Mrs. Durand's learners.

The excerpt above generally shows that Mrs. Durand was focused on covering the curriculum for learners to get marks rather than developing conceptual understanding in her learners. This is evidenced by the following statements that she made during her teaching. *"Here we are going to put in genotypes", "Okay, I am just going to put stuff down, do not worry because we will work out the cross eventually okay.", "You always use the same symbols…for whatever characteristic you look at in this section of your work.", Now ↑to make it easy to remember okay you will draw this…every time you do a genetic cross, you are going to draw a sperm okay and an ovum."* During her demonstrations, Mrs. Durand did not explain why she was writing the genotypes the way she did and why she was using the same symbols for the same characteristic. She was only interested in her learners getting the format for presenting a genetics cross right which she emphasised by modulating her voice using a higher pitch. In this study, there were multiple instances where concepts were just stated not explained and connected in Mrs. Durand and Mrs. Letsiba's classrooms. This provided evidence that these two teachers were focused on teaching learners for marks instead of developing conceptual understanding in their learners.

Example 2: Conceptual development

The sequences below provide an example of an episode where the teacher dealt with the concept of genetic cross-conceptually. The excerpt below was extracted from episode 3 of Mr. Zulu's Lesson Observation 2 where he taught conceptually the concept of genetic cross.

Mr Zulu LO2: Genetic cross-format

106.	*Mr. Zulu:*	*So, for this one… [pointing to the word brown on the transparency] …it is said to be heterozygous, heterozygous how are we going to represent the alleles? Yes, Alumba?*
107.	*Alumba:*	*Capital B and small b.*
108.	*Mr. Zulu:*	*It is capital B and a small letter b.*
109.		*Okay, between the two which one is dominant here and which one is recessive? Yes? [Pointing to a learner]*
110.	*Alumba:*	*The capital B is dominant.*
111.	*Mr. Zulu:*	*This one is dominant and this one is recessive.*
112.		*Let us check this one okay which one is dominant, and which one is recessive?*
113.	*Ls:*	*They are both…*
114.	*Mr. Zulu:*	*They are both dominant okay, they are both dominant.*

115.		*^Now, we should start with our crossing.*
116.		*Boys you are-- you still remember sexual reproduction…we said in sexual reproduction… two gametes will come together.*
117.		*It will be a sperm from the father a:nd an egg…from the mother.*
118.		*Right, so it means that even here we must represent that, we must show the process meiosis.*
119.		*We have to say that meiosis is taking place okay meiosis is taking place.*
120.		*After meiosis what are we going to have, we will have…*
121.	*Alumba:*	*Mitosis!*
122.	*Mr. Zulu:*	*^Ahh… NO! No!*
123.		*Not mitosis.*
124.		*What is going to be formed?*
125.	*Ls:*	*Four cells!*
126.	*Mr. Zulu:*	*Okay, it is fine but then at the end those four cells will what-- THE GAMETES!*
127.		*Right, so what… are we going to have as our gametes here any idea?*
128.	*Mpho:*	*Eye colour sir. [Pointing to the transparency]*
129.	*Mr. Zulu:*	*[Smiling] Okay so because we are looking are at the eye colour only so, it means even our gametes will be representing our eye colour and the gametes… boys they are the same as the genotype.*
130.		*The only difference…now is that you will BE using a circle.*
131.		*Right, so we have this B and we have another B and we put this B in a circle ^we also put this one in a circle, because they have to come together that is why we use this sign which is like a multiplication sign.*
132.		*Then we have this one which will be capital letter B and a ^small letter right, and we put them in a circle and the reason for that…it is because these are gametes …these are gametes, am I making sense?*
133.		*It is the gametes that will come together to form an offspring.*
134.		*Remember we want to see how the child is going to be in this case, right we want to see how the child…is going to be.*
135.		*So, it is the gametes that will come together, it is not just these genotypes and the phenotype.*
136.		*You cannot put two parents together and expect a .child to come out.*
137.		*There must be copulation and during copulation a sperm will be released and then an egg will meet and then we have a process of fertilization.*

Mr. Zulu LO2, episode 3

The excerpt above was extracted from an episode that alternated between dialogue and monologue. To develop the concept of a genetic cross, the teacher used an example of eye colour that was chosen by the learners for consideration. Together with his learners, through the **Teacher question series** Mr. Zulu, started developing an example of a genetic cross by connecting the concept of heterozygous to alleles which were represented using upper case letter B (dominant) and lower case b (recessive) as symbols (turns 106-112). They did that together to determine the genotypes of the two parents they were going to cross (turns111-114). After this, Mr. Zulu confirmed that they were ready to start their crossing (turn 115). However, before the crossing, he linked the concept reproduction to meiosis and consolidated through

logical exposition in a teacher monologue (turns 115-120) to show his learners how gametes are brought about in the genetic cross. The monologue was then transformed into a dialogue as the teacher used a **teacher question series** to further connect meiosis and the gametes into their genetic cross (turns 121-128). To develop the next step of the genetic cross which was fertilization, Mr. Zulu discussed it as linked to the actual process of fertilization and emphasised that there has to be copulation before fertilization can take place. He made these connections through consolidation using **logical exposition** in a monologue (turns 137-140). Overall, the excerpt above provides evidence that Mr. Zulu was exceptional in the sense that he was involved in conceptual development where other teachers would simply teach procedurally. The next section presents the social interaction strategies that were used in this study.

7.5 Social Interaction Strategies

This study uncovered two types of social interaction strategies viz, thematic control strategies and structural control strategies. Thematic control strategies are used by teachers to manage the learners' behaviour in terms of the presentation of the subject matter content while structural control strategies are used to manage learners' behaviour in terms of the classroom activity structure.

7.5.1 Thematic Control strategies

These are strategies used by teachers to manage their learners' attentiveness and the topical content in question (Lin & Lo, 2017). In this study, thematic strategies included **marking importance**, **marking old information/marking new information**, **regulating difficulty**, and **creating mysteries**.

Marking old and new information

Teachers get increased learner attention to the discussion in question by warning them that what is being said is that what is being asked is "old information" that they are assumed to already have grasped (Tang, 2017). When teachers do this, they put pressure on learners and suggest that perhaps they already know enough to participate successfully in the discussion in question (Lemke, 1990). **Marking old information** was the most predominant thematic strategy in all four teachers' practices. This could be because all teachers reviewed the topic of mitosis which was covered in grade 10. **Marking new information** increases the learners' attentiveness to the topical discussion by indicating that what the teacher is saying is providing new information for the first time and is meant to stimulate learner interest (Tang, 2017). All four teachers in this study marked new information. Marking new/old information is important in the sense that the teacher relates a concept in the ongoing explanation to some concepts that were discussed earlier assisting in forging continuity and coherence (Tang, 2017). Thus, by employing the marking old and new information strategy, the teachers in this study, created an environment that allowed continuity and coherence of genetics concepts.

Marking importance

This thematic strategy provides information about the topical content and is used to manage learner behaviour by increasing attentiveness since it identifies the most important aspects of the topic (Tang, 2017). **Marking importance** was the second predominant thematic strategy (occurring in all teachers' practices) with the most instances recorded in Mrs. Durand's practice while Mr. Zindi recorded the least. For instance, Mrs. Durand's practice was associated with statements like *"…this terminology is very important"*. In the hands of the best teachers, marking importance would display a dual function where the teachers choose the best moment to emphasise the importance of particular concepts to obtain the best effect on learners' behaviour (Lemke, 1990).

Regulating difficulty

According to Lemke (1990) when using this strategy, teachers selectively pose easier or more difficult questions in a bid to manage learners' behaviour. In other words, when a teacher asks a relatively easy question learner participation increases while asking a relatively difficult question tends to make learners pause and think deeply. Ong et al. (2016) refer to the concept of **regulating difficulty** as a technique of focusing and zooming which allows teachers to adjust the nature of their questions based on the learners' responses. In this study, **regulating difficulty** was associated with **teacher question series** and was a rare strategy since it was used by Mr. Zindi and Mr. Zulu only. According to Lemke (1990), in the hands of good teachers, questions are adjusted to learners' responses with each successive question building on the preceding ones to assist their learners in progressively constructing an integrated framework if ideas. Hence, Mr. Zindi's and Mr. Zulu's practices had the potential to help learners construct an integrated framework of ideas (Tofade et al., 2013).

Creating mysteries

Science is one of the many ways in which human curiosity surfaces (Pritchard, 2018). Thus, **Creating mysteries** is a thematic strategy employed by teachers to draw learners' attention towards the topical content (Lemke, 1990). In this case, the teacher withholds information about a topic or concept while offering only clues to build suspense. Creating mysteries as a strategy is important in science for the following reasons: it generates curiosity, and cognitive conflict, promotes affective engagement, and promotes the use of inquiry skills as they try to solve the mystery (Carpineti et al., 2015). Nonetheless, this study revealed this strategy as rare, used only in one of Mrs. Durand's lessons. This finding suggests that learners in this study were not afforded opportunities for promoting affective engagement, developing inquiry skills, and generating cognitive conflict and curiosity (Carpineti et al., 2015).

7.5.2 Structural Control Strategies

Modern-day reforms consider education to be effective when it is focused on the acquisition of knowledge and skills (Trauth-Nare et al., 2016). Ultimately, this generalised educational objective hinders, the possibilities of developing human relations that encourage meaningful engagement in science education (Evans & Vaandering, 2022). To foster the acquisition of knowledge and skills teachers employ structural strategies which assist them to manage their learners' behaviour (Axelsson & Jakobson, 2020). In this study, teachers used **admonition sequences** (ADM), **controlling pacing** (CP), **interrupting learners** (IL) **signalling boundaries** (SB), **getting personal (GP)** and **being funny** (BF**).** According to (Lemke, 1990) these strategies are used by teachers to focus on the acquisition of knowledge at the expense of building relations with their learners that would encourage meaningful engagement in their classrooms. Learning is basically a social process, where talking to one another in small groups or side talk provides learners with an opportunity to talk science in a way that is free of the pressures of talking to the teacher (Tomlinson, 2014). Therefore, effective teachers would acknowledge this by overlooking side talk. Nonetheless, in this study, Mrs. Durand and Mrs. Letsiba frequently used **admonition sequences** to discourage learners from talking to one another. It is important to note that there was no evidence of groupwork in the four teachers' practices. This suggests that these teachers did not create environments that supported learning to be a social process. Perhaps Mrs. Durand and Mrs. Letsiba admonished their learners more for side talk because it is considered to be disrespectful to the teachers or any individual talking and learners tend to miss out on important things when engaging in side talk (Lemke, 1990). This concurs with what Mrs. Durand said during her interview session about her expectations during the lessons.

111.	*R:*	*So, what do you expect from your learners in your classroom during lessons?*
112.	*Mrs Durand:*	*My lesson, my first thing is when I talk, you keep quiet.*
113.		*You must listen and when I ask you to do something, you are not chatting, you are doing it.*
114.		*So, I can assist you where you struggle.*
115.	*R:*	*Ehm.*
116.	*Mrs Durand:*	*But my big thing is silence when I am talking because you are taking away from the person next to you.*

Mrs. Durand INT

The excerpt above shows that Mrs. Durand strongly expressed her view about her expectation of learners being quiet during her teaching. This provides evidence of how much she intended to discourage side talk during her lessons. Similar sentiments were also echoed by Mr. Zindi who was from the same school as Mrs. Durand though what I observed in Mr Zindi's practice contradicted these sentiments since his classroom was associated with the fewest **admonition sequences**. Perhaps it was part of the school policy that there should be silence during lesson time. Discouraging side talk during lessons is considered to be bad practice as mentioned above. This suggests that Mrs. Durand created a classroom environment that did not support learning as a social process.

Teachers in this study managed their learners' behaviour by using a strategy known as **controlling pacing.** According to Lemke (1990) on the one hand, learners' interests are inclined towards the teachers teaching them the least material and making sure that they have mastered it before proceeding to the next topic. On the other hand, teachers tend to be interested in covering more material during the lesson. Thus, teachers tend to ignore their learners' interests and support those of the curriculum, which commands that specified content be covered by a given time despite how well it has been learned (Lemke, 1990). As a result, learners have no control over pacing (Lin & Lo, 2017) leading to teachers covering too much work quickly for many of the learners to master (Lemke, 1990). By using **controlling pacing** more, Mrs. Durand and Mrs. Letsiba did not consider their interests and thus, did not afford all learners ample time to master the 'genetics' concepts taught.

Interrupting learners as a strategy is related to **admonition sequences** and **controlling pacing** was rarely used in this study. In this study, Mrs. Letsiba interrupted learners' Discourse more as they tried to speak to one another or when learners seemed to be taking more time to answer given questions. As a result, as discussed earlier she afforded opportunities to express themselves as they tried to talk about science with their peers or teachers (Lin & Lo, 2017). Furthermore, teachers have the privilege of controlling the activity in effect at any given time as they declare boundaries between activities or shift the lesson from dialogic to authoritative Discourse (Scott et al., 2006) as discussed in Chapter 6 or dialogue to monologue.

Humour is a key social lubricant which curtails social friction that may be produced by teachers Discourse moves when there are conflicting interests between the teacher and learners (Lemke, 1990). Accordingly, in this study, teachers used humour in concert with **admonition sequences** to mitigate the blow to the learners' egos. The most common social interaction strategies **being funny and getting personal** which are usually used simultaneously. The most instances of **being funny** and **getting personal** were recorded in Mrs. Letsiba's classroom. This suggests that Mrs. Letsiba created an environment that had the potential to mitigate the blow of learners' egos in her classroom. The sequences below provide an example of a scenario where the teacher used a variety of social strategies during teaching.

Mrs. Durand LO1 (Lesson Observation 1): Meiosis

The episode below was extracted from Mrs. Durand's Lesson Observation 1 where she was focusing on meiosis terminology[14]. In doing so, she engaged in a variety of Discourse strategies whose discussions follow.

198.	*Mrs. Durand:*	*↑We are now going to focus on the terminology that we need for meiosis, some of which will be similar here, but I am going to give the actual term and the definition.*
203.		*I did not tell you to talk, the fact that I turned around does not mean you talk. [Pause]*
204.		*Okay, our terminology that we are going to use—is first— I am going to write them in order.*
205.		*Diploid which I already mentioned so this is meiosis terminology*
206.		*There is still a person mumbling and you are irritating me [stops writing and looks at the learners].*
207.		*Okay, [writing on the board] we can call these two sets of chromosomes in a cell and we refer to this as 2n, double the number.*
208.		*Then we are going to have haploid okay, we going to refer to this as just n.*
209.		*In other words, HALF the number of chromosomes.*
210.		*We also going to look at again somatic CELLS ↑all cells of the body EXCEPT for the sex cells.*
211.		*Okay …there is one, two three terms already. [Looks into her book]*
212.		*I am going to continue this side. [Erasing the board]*
213.		*I am going to use the term autosomes.*

[14] Mitosis, meiosis, chromosomes, diploid, n, 2n, cells, autosomes, sex gamete, sex cell, sperm, ova, sex chromosomes, gonosomes, XY, XX, chiasma, organism, testis, organs, and ovaries

214.	*"It is a chromosome that does not determine the sex of an individual".*
215.	*I am going to come back to why I am saying that okay,*
216.	*Then we are going to have gamete THAT IS A "SEX CELL" GUYS, it is either a sperm or an ovum, ovum singular, ova plural alright singular here okay and ova plural.*
217.	*Then we have gonosomes, these are the "SEX chromosomes of an individual"...*
218.	*That is either a X or a Y okay, male XY—will be female XX, male XY*
219.	*Okay you got that [Puts the book down and pointing to the terms on the board] very important terminology that we will be using and there are others coming as well.*

Mrs. Durand LO1, episode 14

The excerpt above was extracted from an episode where Mrs. Durand focused on structuring the logic in the subject as she dealt with the definitions of 'meiosis terminology[7]. Nonetheless, this type of engagement does not help learners form a clear understanding of the concept of the process of meiosis since it results in superficial knowledge of the vocabulary words. To deal with definitions of the terminology, she signalled boundaries (turn 198), marked importance (turn 219), and admonished her learners (turns 203, 206). The **marking importance**, **marking new/old information**, and **signalling boundaries** strategies were evident in all four classrooms. The finding about **marking importance** is consistent with Axelsson and Jakobson (2020) who maintain that it is common practice for teachers to indicate the importance of the discussion in question. Lemke (1990) argues that in the hands of great teachers, **marking importance** legitimately plays a dual function where the teacher simply gets the best time to emphasise the importance of a concept to produce the greatest effect on learner behaviour. In my opinion, this was a good practice displayed in all classes as teachers used the strategy for marking important points and trying to get their learners' attention. Similar to **marking importance**, another common strategy used in all classrooms in this study was **marking new/old information**. According to Lemke (1990), **marking new/old information** has an advantage to the teacher who uses it to get learners' attention to the current discussion. Nonetheless, this strategy has the advantage of stimulating interest and putting pressure on the learners as it reminds them that they are expected to know the concepts in question. On this account, it can be concluded that the use of **marking importance** in Mrs. Durand's classroom fulfilled her expectations of getting the learners' attention since they remained quiet and listened to the teacher throughout the episode. This expectation was made clear during Mrs. Durand's interview session as shown in the following excerpt.

111.	*R:*	*So, what do you expect from your learners in your classroom during lessons?*
112.	*Mrs Durand:*	*My lesson, my first thing is when I talk, you keep quiet.*

113.		*You must listen and when I ask you to do something, you are not chatting, you are doing it.*
114.		*So, I can assist you where you struggle.*
115.	*R:*	*Ehm.*
116.	*Mrs Durand:*	*But my big thing is silence when I am talking because you are taking away from the person next to you.*

Mrs. Durand INT

However, in Mrs. Durand's classroom, the strategy of **marking importance** did not seem to assist in stimulating the learners' interest on them since there was no evidence of any learners' participation in episode 14 under discussion. To stimulate interest the teacher could have engaged her learners in a dialogue. Overall, teachers in this study used **marking importance**, **marking new/old information**, and **signalling boundaries** in two different ways. Mrs. Durand and Mrs. Letsiba used **marking importance** together with **interrupting learners** and **admonition** as a discipline measure to maintain the structure of the activities while Mr. Zulu and Mr. Zindi used it for emphasising importance and stimulating interest.

In episode 14 above Mrs. Durand mainly used **admonition** to discourage side talk. This observation is consistent with Mrs Durand's expectations evident in the interview excerpt discussed earlier. Perhaps she did this because side talk is considered to be disrespectful to the teacher or whoever is talking and one tends to miss out on important things (Lemke, 1990) during the lesson. However, side talk provides learners with opportunities to talk about science in a way that is free of the pressures of talking to the teacher Lemke (1990). In this study, all the teachers except Mr. Zindi admonished side talk. This finding suggests that Mr. Zindi created an environment which offered his learners an opportunity to have side conversations and talk about science differently. Contrary to admonishing side talk, Mrs. Durand and Mrs. Letsiba did not admonish calling out or chorus answers. However, Mr. Zulu admonished and discouraged calling/chorusing by encouraging learners to raise their hands whenever he asked questions to bid to answer or wait for nomination. According to Lemke (1990), calling out serves the learners' interests by reducing the anxiety of speaking formally and being on the spot when one's response is wrong reducing the teachers' direct power over their learners by pre-empting their power to nominate learners. Mr. Zulu's reasoning about encouraging learners to raise their hands whenever he asked questions is presented in the excerpt below extracted from his interview transcript.

216.	*R:*	*Okay, you…also encouraged them to raise their hands, why ehh…why is this important to you?*
217.	*Mr Zulu:*	*Yeah…this one is very important for me, and I have been doing it ever since I started teaching because ehh…I am trying to maintain order.*
218.	*R:*	*Yes!*

219.	*Mr Zulu:*	*In class, you know with these learners, when they get too excited about a section or about the topic.*
220.		*Once they feel like they understand it, they want to answer even if ehh…it does some effect in terms of managing my class.*
221.		*So, it is part of my classroom management strategies, I would say.*

Mr. Zulu INT

The extract shows how Mr. Zulu's strong views about the need for learners to raise their hands in a bid to answer his questions. For Mr. Zulu, encouraging learners to raise their hands, is his classroom management strategy that helps him to maintain order. Thus, Mr. Zulu uses admonition as his survival skill serving his interests, not the learners' (Lemke, 1990). This finding suggests that by ignoring calling out/chorusing, Mrs. Durand and Mrs. Letsiba created environments that had the potential to reduce the learners' anxiety about speaking formally to the class as well as being on the spot their responses are wrong while Mr. Zulu and Mr. Zindi whose focus was on conceptual development did not.

An example of **getting personal and being funny** unfolded in Mrs. Letsiba's Lesson Observation 1, episode 1 when she was recapping 'meiosis' is presented below. The following sequences were extracted from an episode where she was focusing on the concepts of metaphase 1 and 2. Thus, the teachers and learners were discussing the events that take place during metaphase 1 and 2.

LO1: Recapping meiosis and abnormal meiosis

105.	*Chinasa:*	*What then happens… what then happens to the [chromosomes] ?*
106.	*Lethabo:*	*It did not— it did not disappear angisho— ["isn't it" in IsiZulu]*
107.	*Mrs. Letsiba:*	*They just ehh…*
108.	*Kamogelo:*	*Went to the centrioles.*
109.	*Mrs. Letsiba:*	*Is it not that they were in what…ehh…was a marriage between them … And then ehh… when [moving close to Jeremy and holds his hand as he stands up] I am getting married to Jeremy.*
110.		*Every now and then when I am moving, I am moving…I am moving with Jeremy 'neh'... that is ehh… our meta- phase 1… going with Jeremy to—ehh… to the equator and I am not going alone.*
111.		*Is it not so…he is my partner?*
112.		*So, we must do what…we must GO ehh… toge-ther … and then at some point [learners laugh] Jeremy is not doing the right thing then I am doing what…I am—I am ehh…divorcing ehh…Jeremy.*
113.		*So, when I am divorcing Jeremy then it is /metaphase/ what…*
114.	*Ls:*	*2!*
115.	*Mrs. Letsiba:*	*…ehh…2 when chromosomes are moving what…all over the place…what…ehh… ((in single))*
116.	*Lethabo:*	*Ma'am can you please start in telophase one— one whereby one cell it now has ehh…haploid?*

Mrs. Letsiba LO1, episode 1

The excerpt above was extracted from episode 1 of Mrs. Letsiba's Lesson Observation 1 where she used the following strategies: **signalling boundaries**, **getting personal** (turns 109-113) and **being funny** (109-113). **Getting personal** and **being funny** were used in concert in this case and this is consistent with findings from a study by Axelsson and Jakobson (2020). The teacher got personal by referring to herself and one learner as she used marriage and divorce to demonstrate the arrangement of chromosomes that take place during 'metaphase 1' and 'metaphase 2' respectively. As discussed earlier, according to Lemke (1990) humour is a key social lubricant which curtails social friction that may be produced by teachers Discourse moves when there are conflicting interests between the teacher and learners. Since Mrs. Letsiba's classroom was associated with more instances of **being funny** it follows that she is the teacher who created an environment that had the potential to diminish the friction that may be produced between teacher and learners during the lessons. However, when not handled properly, the **getting personal** strategy may constrain the learning process.

7.6 Multimodal Representations

In this study, multimodal representations refer to the different forms of communication used by teachers during the construction of semantic relations during the teaching of genetics. Teachers in this study, when constructing semantic relations, made use of gestures multimodal representations such as **verbal**, **visual** and **gestures**. This finding is consistent with research (Treagust & Tsui, 2013; Treagust et al., 2017) where **visual representations** were found to be deployed in concert with **verbal** as well as **gestural representations**. When fused during teaching, multimodal representations may assist learners in understanding the abstract of the natural phenomena that may not be crystal clear from each representation (Won et al., 2014). Furthermore, multimodal representations have the potential to assist learners in constructing a deeper conceptual understanding of biology concepts such as developing reasoning skills, constructing and understanding concepts like phylogenetic trees (Treagust et al., 2017). Nonetheless, teachers need to integrate the meanings behind representations, otherwise, these representations can confuse the learners (Cheng, 2015). The multimodal representations evident in this study are shown in Figure 7.4.

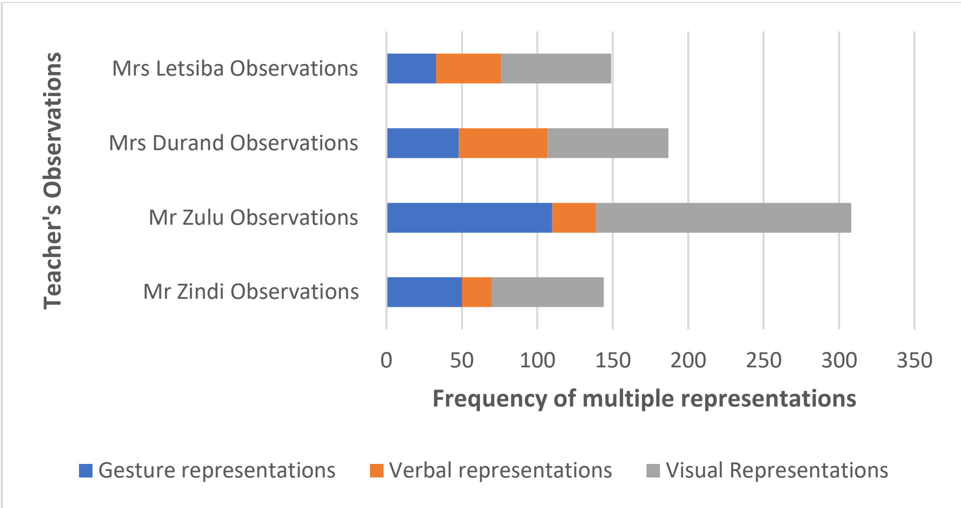

Figure 7. 4: Multimodal representation strategies and their frequencies per teacher

Figure 7.4 shows that **visual representations** were the most frequently used in this study with Mr. Zulu recording the highest. According to Opfermann et al. (2017) numerous science processes, concepts, and relationships can be understood faster when some form of a picture is brought forth because pictures can present at once what would take a longer time to be described in words. Moreover, visual representations provide learners with opportunities to visualise abstract concepts of science such as chromosomes and alleles in genetics. Mr. Zulu seemed to concur with the notion of visual representations during his interview session when he was asked about the importance of images in his teaching.

343.	*R:*	*I also saw that when you were teaching dihybrid inheritance you also had the…the punnet square and you also had some images ahh…when you were teaching what is the last thing?*
344.		*Ehh…the pedigree diagram, why do you think images are important in teaching?*
345.	*Mr Zulu:*	*Yaah…you know what ehh…I think images neh…they are very important; you know most of our learners neh…*
347.		*…ehh…they get interested if…*
349.		*…they get again…if you are going to ehh…play a video for them with these images, they also sort of help in ehh…enhancing their understanding or they help support the content.*
351.		*And they become more interested you know.*
353.		*It becomes boring to just look at ehh…just words that are full of ehh…ehh…that are full in that ehh…project…data projector.*
355.		*So, it is better to sort of like try to enhance with images and you know with diagrams neh…because you know in the exams, they use diagrams.*
357.		*So, they have to get to understand some of the diagrams although in the exams some of the diagrams might be lot different from mine, but I even feel like ehh…images, help a lot to…boost their understanding of the section.*
358.		*That is why I usually use images, in fact in most of my notes I use images.*
359.	*R:*	*Yaah…first…*

360. Mr Zulu: Yaah…

361. R: Yes! Go ahead.

362. Mr Zulu: And again, with these…I am saying that again these learners are not the same.

363. Some are very good at just understanding the content without images, you know.

365. You know there are some learners who need to watch or actually see how something looks like.

366. So, that is why I prefer to also use images since I have different kinds of learners with different ehh learning strategies as well.

Mr. Zulu INT

The excerpt above shows how Mr. Zulu strongly expressed his view about the role of images (visual representations) in the teaching of science. The excerpt provides the reasoning behind Mr. Zulu's extensive use of images in his presentations during the teaching of 'genetics'. He emphasised the importance of images in enhancing or boosting his learners' understanding and linked the use of images to examinations. He also added that the use of images appeals to some learners since different learners have different learning styles which is consistent with Opfermann et al. (2017) who maintain that when multimodal representations are used, learners can choose the one that appeals to them. The other three teachers echoed the same views as Mr Zulu's regarding the importance of images which also provided their reasoning for the use of images in their classrooms. I believe that their rationale for their intense use of visual representations when focusing on this topic was also based on the common genetics concepts that they all dealt with viz, the structure of the chromosome, the process of meiosis, and monohybrid crosses. These concepts demanded that the teachers include images of chromosomes and cells to show different phases of meiosis and representations to show genes, alleles, genetic makeup, and the format for working out genetic crosses. It would be practically impossible for the four teachers to teach these concepts without visual representations.

This study uncovered **verbal representations** such as extra stress, higher/lower pitch and dragging of words (voice modulations), where extra stress was common to all four teachers. Teacher voice modulations are essential tools for maintaining learners' attention and interest (Gautam et al., 2022). Thus, all four teachers in this study used their voices to maintain their learners' attention and interest. In this study, **gesture representations** were used concurrently with **verbal** and **visual representations**. This result concurred with Cartmill (2022); and Treagust and Tsui (2013) who maintain that the teachers' use of gestures is a common non-verbal behaviour in science classrooms. According to Cartmill (2022), gestures are intricately connected to language and thought, thus it can be considered a tool for communication and cognition, consequently supporting problem-solving and learning. Hence, most of the gestures used in this study were related to the ‘genetics’ concepts in question. For instance, the teachers in this study pointed to their bodies when they were focusing on the term phenotype and raised one finger when dealing with the concept of monohybrid crosses. In the following interview excerpt, Mr Zindi provides the reasoning behind his use extensive use of gestures.

275.	*R:*	*Okay, I have noticed that you use ehh…a lot of gestures.*
276.		*Sometimes you use your hands, sometimes ahh…you smile at your learners or nod your head.*
277.		*Does this…how does this assist your teaching?*
278.	*Mr Zindi:*	*It aah…affects in a positive way because when you use gestures you…the learners can actually see the emphasis that you are putting on certain or particular concepts during the lesson.*
279.		*So, if you just stand still and you do not change your voice, you do*
not		*show any…what do you call it?*
280.		*Any body language.*
281.	*R:*	*Ehm.*
282.	*Mr Zindi:*	*Then, the learners will not know which ehh…concept to put more emphasis on but when you do that you are now emphasising.*
283.		*You are giving them a clue of which concepts are important to take note of.*

Mr. Zindi INT

As can be seen from the excerpt above, Mr. Zindi strongly believed that gestures play a pivotal role towards focusing his learners on the most important concepts of the topic in question. This finding is consistent with Cartmill (2022) who argues that gestures influence the listeners’ interpretation of speech since they reinforce spoken meaning. This results in them perceiving and recalling information than when speech is not accompanied by gestures. The excerpt further provides evidence that the use of gestures is linked to the social strategy of marking importance because he said that he used gestures to mark important concepts during his teaching. Next, I present the analysis of observations in terms of multimodal representations.

The sequences below were extracted from episode 1 (LO1) where Mrs. Letsiba revisited the concept of meiosis. In particular, the excerpt below shows how Mrs. Letsiba was trying to assist her learners in internalizing the link between metaphase 1 and 2.

LO1: Recapping meiosis and abnormal meiosis

92.	*Mrs. Letsiba:*	*Can you wait…ehh… I want you to help him just explain what ehh…METAPHASE 1 is all about neh (“isn’t it” in Afrikaans) …anyone…*
93.	*Sifiso:*	*Ma’am like ehm…the chromosomes align themselves along the equator in homologous pairs in metaphase 1 but then in metaphase 2 they align themselves as singly meaning…/ ? /*
94.	*Mrs. Letsiba:*	*Ehh…one person at a time ehh…Lethabo*
95.	*Lethabo:*	*In metaphase 1 neh (“isn’t it” in Afrikaans)…they align themselves in [using hands]*
96.	*Mrs. Letsiba:*	*Can you come?[Lethabo goes to the board]*
97.	*Lethabo:*	*Eeh…madam!*
100.		*Madam /we can ask a question/ is there one difference in metaphase 1 and in metaphase 2?*

101.		*I say yes because in metaphase 1 ma'am [drawing on the board] these are centrioles, spindle fibres.*
102.	*Kamogelo:*	*Spindle fibres.*
103.	*Lethabo:*	*Okay [drawing on the board] …these are your homologous pairs right they are lining pairs…pairs neh ("isn't it" in Afrikaans) …and then in metaphase 2 it's are no more in pairs, [erasing the other chromosome from the diagram] its singly…one chromosome… [smiling and using hands] …you understand what I am saying?*
104.	*Mrs. Letsiba:*	*Ehh… let us hear from ehh… [points to a learner]*
105.	*Chinasa:*	*What then happens… what then happens to the [chromosomes] ?*
106.	*Lethabo:*	*It did not— it did not disappear angisho— ["isn't it" in IsiZulu]*
107.	*Mrs. Letsiba:*	*They just ehh…*
108.	*Kamogelo:*	*Went to the centrioles.*
109.	*Mrs. Letsiba:*	*Is it not that they were in what…ehh…was a MARRIAGE between them ... And then ehh… when [moving close to Jeremy and holds his hand as he stands up] I am getting married to Jeremy.*
110.		*Every now and then when I am moving, I am moving…I am moving with Jeremy 'neh'... that is ehh… our META- PHASE 1… going with Jeremy to--ehh… to the EQUATOR and I am not going alone.*
111.		*Is it not so…he is my partner?*
112.		*So, we must do what…we must GO ehh… toge-ther ... and then at some point [learners laugh] Jeremy is not doing the right thing then I am doing what…I am—I am ehh…DIVORCING ehh…Jeremy.*
113.		*So, when I am divorcing Jeremy then it is /METAPHASE/ what…*
114.	*Ls:*	*2!*
115.	*Mrs. Letsiba:*	*…ehh…2 when chromosomes are moving what…all over the place…what…ehh… ((in single))*
116.	*Lethabo:*	*Ma'am can you please start in telophase one— one whereby one cell it now has ehh…haploid?*

Mrs. Letsiba LO1, episode 1

The excerpt above shows how Mrs. Letsiba used **verbal** (92, 109, 110, 112, 113) **gestures** (95, 101, 103, 104,109) and **visual representations** (101, 103, 109-113) in concert. In particular, the excerpt shows Mrs. Letsiba trying to use board work (turn 103) where a learner was asked to draw a diagram (**visual representation**) on the board to show the arrangement of chromosomes during 'metaphase 1'. However, Mrs. Letsiba did not acknowledge or use the learners' board work to develop the concepts of metaphase 1 and metaphase 2. Instead, Mrs. Letsiba moved on and nominated another learner (Chinasa) to continue with the discussion. This action by the teacher provides evidence that Mrs. Letsiba did not focus conceptual development-focused but assessment-focused. In terms of the use of multimodal representations, Mrs. Letsiba's practice stood out through her use of the analogy of marriage and divorce in the form of **role play** to represent the movement of chromosomes during 'metaphase 1' and 'metaphase 2' respectively. In Mrs. Durand's classroom, there was one instance where she introduced an analogy of the 'Doppler effect ' as used in physical science but failed to relate it to Mendel's experiments that she was referring to. According to Abed (2016), **role play** is seen as one of the most inspiring and powerful strategies that can improve learners' comprehension of science concepts. Therefore, the inclusion of **role play** in Mrs Letsiba's practice made her practice outstanding for creating an environment that had the potential to inspire and provide opportunities to improve learners understanding of science concepts. However, Cheng (2015) argues that if one fails to integrate the meaning behind representations, they can confuse the learners. Hence, use of the use of the 'marriage divorce' analogy in Mrs. Letsiba's classroom may have caused confusion as evidenced by Lethabo (Turn 116) who requested the teacher to go back to 'telophase 1' after the use of the analogy. So, Mrs. Letsiba was supposed to explain the meaning behind her analogy so that learners could transfer, the semantic relations from the familiar Thematics of marriage and divorce to unfamiliar Thematics about the movement of chromosomes during 'metaphase1 and 2'. Overall, in terms of multimodal representations, Mrs Letsiba modulated her voice through the use of extra stress, and dragging (**verbal representations**) to maintain learners' attention and interest (Gautam et al., 2022). Her use of **gesture representations** created an environment that had the potential to support problem-solving, and learning (Cartmill, 2022). Lastly, according to Opfermann et al. (2017) numerous scientific processes, concepts, and relationships can be understood faster when some form of a picture is brought forth because pictures can present at once what would take a longer time to be described in words. Therefore, Mrs Letsiba, like the other three teachers in this study, created environments that had the potential to maintain attention and interest, support problem solving and faster learning. On being asked why she used drama in the teaching of genetics during her interview session, Mrs. Letsiba had this say.

198.	*R:*	*Yah…so, I guess that is the reason also you use ehh… sometimes drama, because in one of the lessons when you were teaching the concept of first filial generation.*
199.		*you asked ehh… your learners to come… some of the learners to come to the front to be children, the offspring and then you asked two learners; a tall one and a short one to come and be the father and mother when you wanted to demonstrate first filial generation.*
200.		*Why do you use demonstrations like this or dramatization like this?*
201.	*Mrs Letsiba:*	*Is it not that I said to you ma'am earlier on…*
202.	*R:*	*Ehm.*
203.	*Mrs Letsiba:*	*… that ehh… learners, they already… when they come to… we they come to the ehh… this section of genetics.*
204.	*R:*	*Ehm.*
205.	*Mrs Letsiba:*	*In their minds they already have this thing that ahh… genetics is a very difficult ehh… topic.*
206.	*R:*	*Ehm… Ehm.*
207.	*Mrs. Letsiba:*	*And the learners tend to lose interest easily.*
208.	*R:*	*Ehm.*
209.	*Mrs Letsiba:*	*Neh!*
210.	*R:*	*Ehm.*
211.	*Mrs Letsiba:*	*So, what I am… I am just trying to motivate ehh… to make the topic interesting.*

Mrs. Letsiba, INT

The extract above shows the reasoning behind Mrs. Letsiba's use of **role play** during her teaching of 'genetics'. It is clear that Mrs. Letsiba understood the difficulties faced by her learners with the topic 'genetics'. Thus, she used **role play** to stir interest in her learners and motivate them. Such reasoning suggests that Mrs. Letsiba was abreast with the research literature which maintains that genetics is a difficult topic (Fauzi et al., 2021; Onowugbeda, 2020). In the next section, I present Discourse Strategies Profiles for each teacher.

7.7 Teacher Discourse Strategy Profiles

In this section, I present teacher Discourse strategy profiles. To come up with these teacher Discourse strategy profiles, I deepened my analysis and looked at the data for each teacher by constructing 'maps' per teacher for each of the three strategy categories viz, thematic development strategies (in section 7.4), strategies for interaction (in section 7.5), and multimodal representation (in section 7.6). Identified combinations of strategies through the teachers' Discourse strategies 'maps' (Figures. 7.5, 7.6, 7.7, 7.8, 7.9 and 7.10) then indicated the teacher types or teacher profiles for classroom Discourse which are discussed in the next sections.

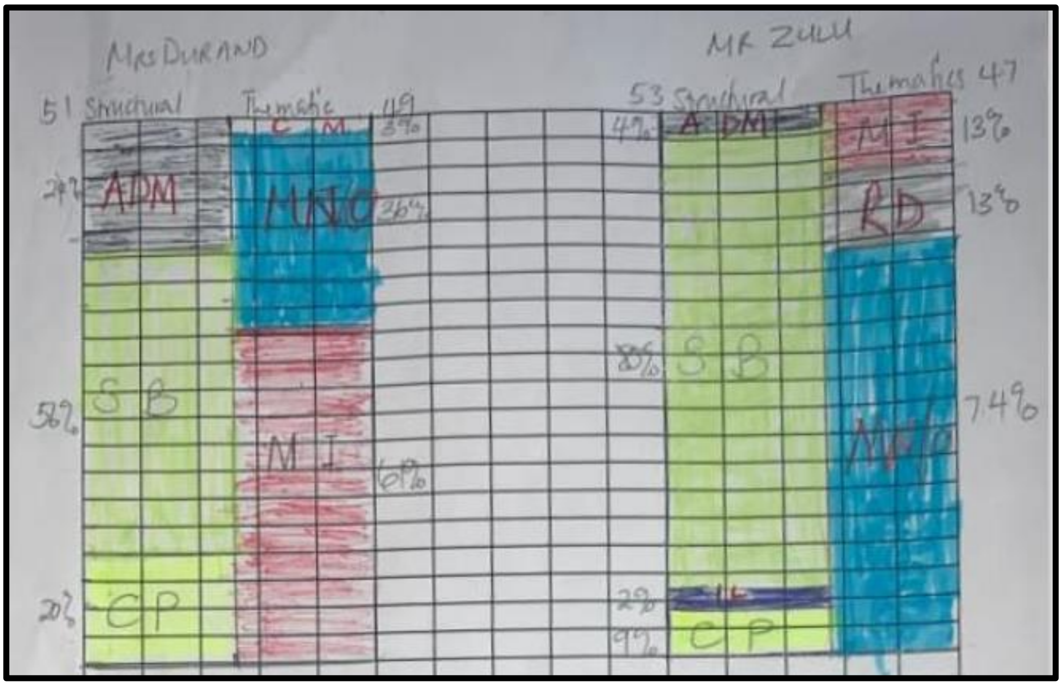

Figure 7. 5: Mrs. Durand's and Mr. Zulu's thematic and structural 'maps'
Where: CP- controlling Pacing, IL- interrupting learners, MN/O-marking new/old information, Signalling boundaries, ADM- admonition, MI-marking importance, RD- reducing difficulty

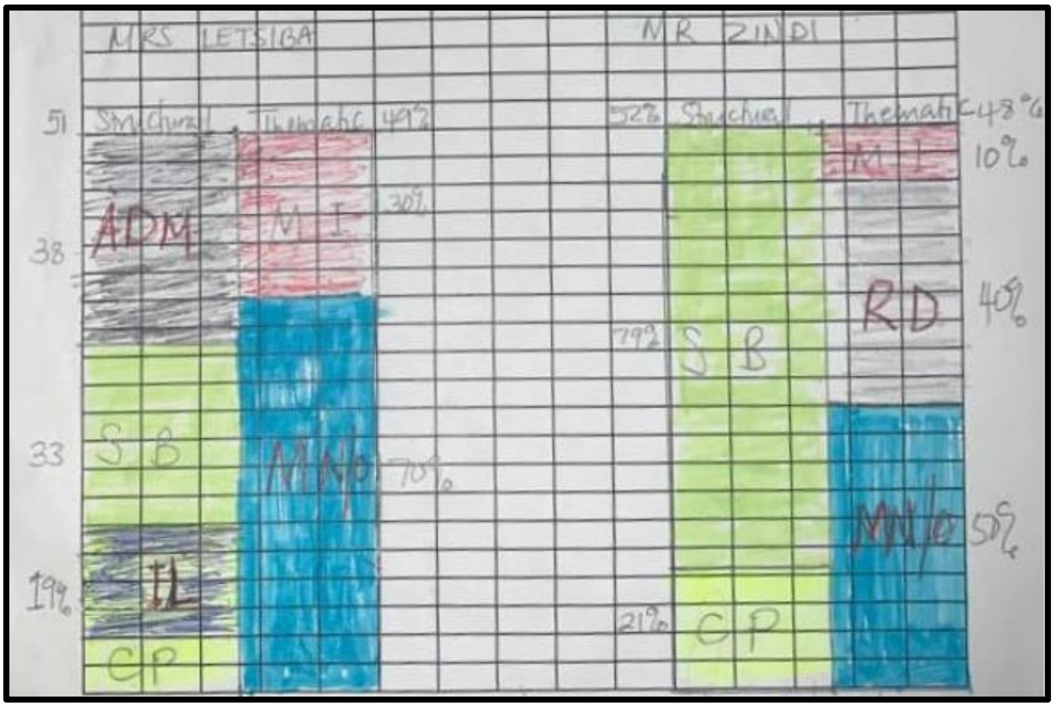

Figure 7. 6: Mrs. Letsiba's and Mr. Zindi's structural and thematic 'maps

Where: CP- controlling Pacing, IL- interrupting learners, MN/O-marking new/old information, Signalling boundaries, ADM- admonition, MI-marking importance, RD- reducing difficulty

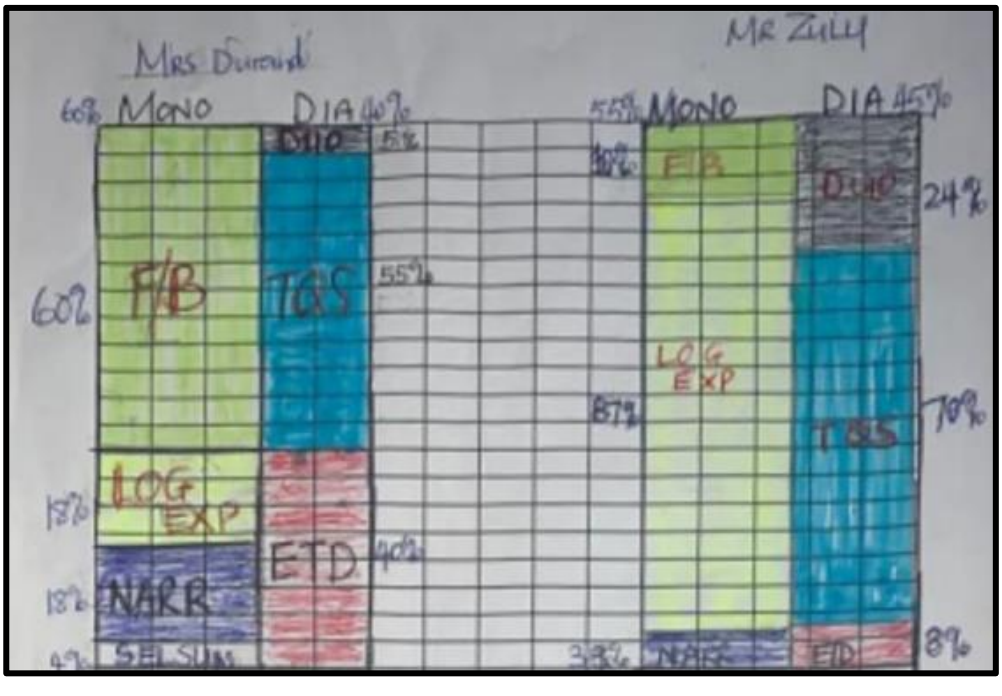

Figure 7. 7: Mrs. Durand's and Mr. Zulu's monologue and dialogue 'maps'

Where: F/B- foregrounding and backgrounding, LOG EXP- logical exposition, NARR-narrative, SEL SUM- selective summary, DUO- duolog, TQS- teacher question series, ETD- external text dialogue, MONO- monologue, DIA- dialogue

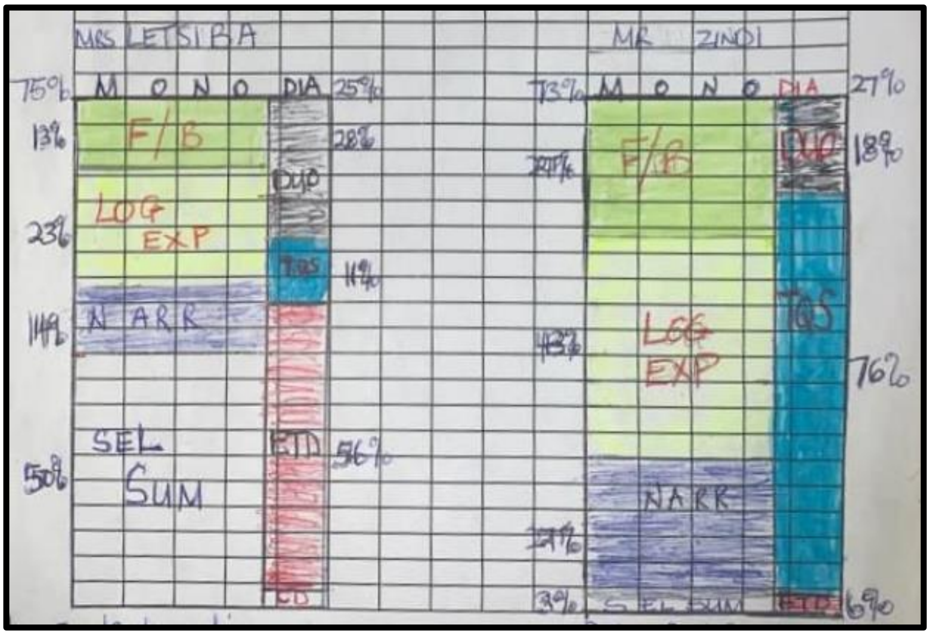

Figure 7. 8: Mrs. Letsiba's and Mr. Zindi's monologue and dialogue strategies 'maps'
Where F/B- foregrounding and backgrounding, LOG EXP- logical exposition, NARR-narrative, SEL SUM- selective summary, DUO- duolog, TQS- teacher question series, ETD- external text dialogue, MONO- monologue, DIA- dialogue

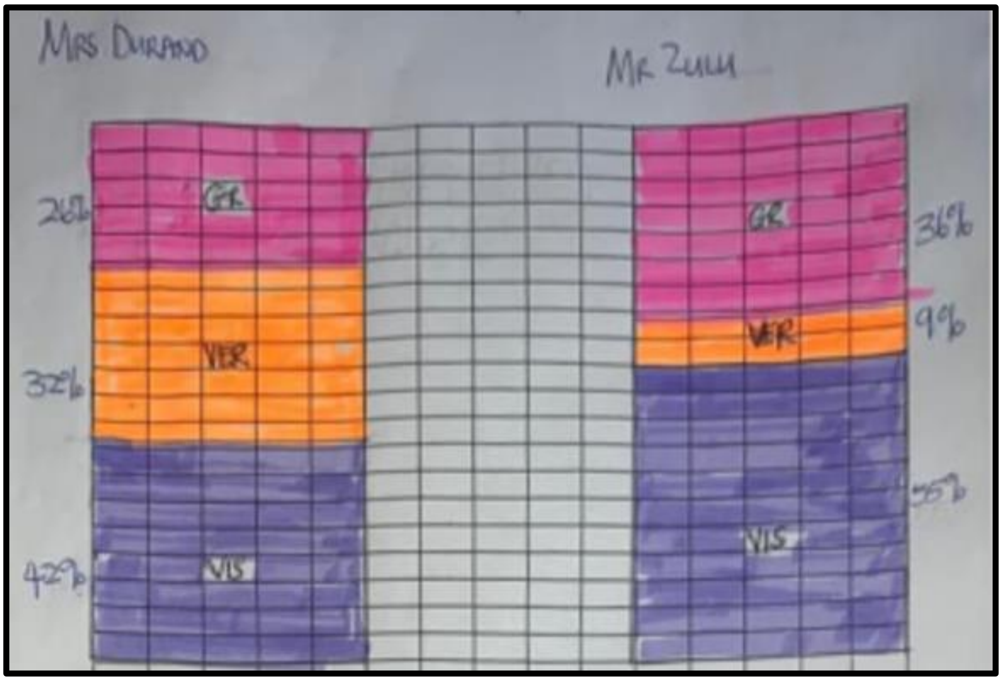

Figure 7. 9: Mrs. Durand's and Mr. Zulu's multimodal representation 'maps'
Where GR- gesture representations, VER- verbal representations, VIS- visual representations

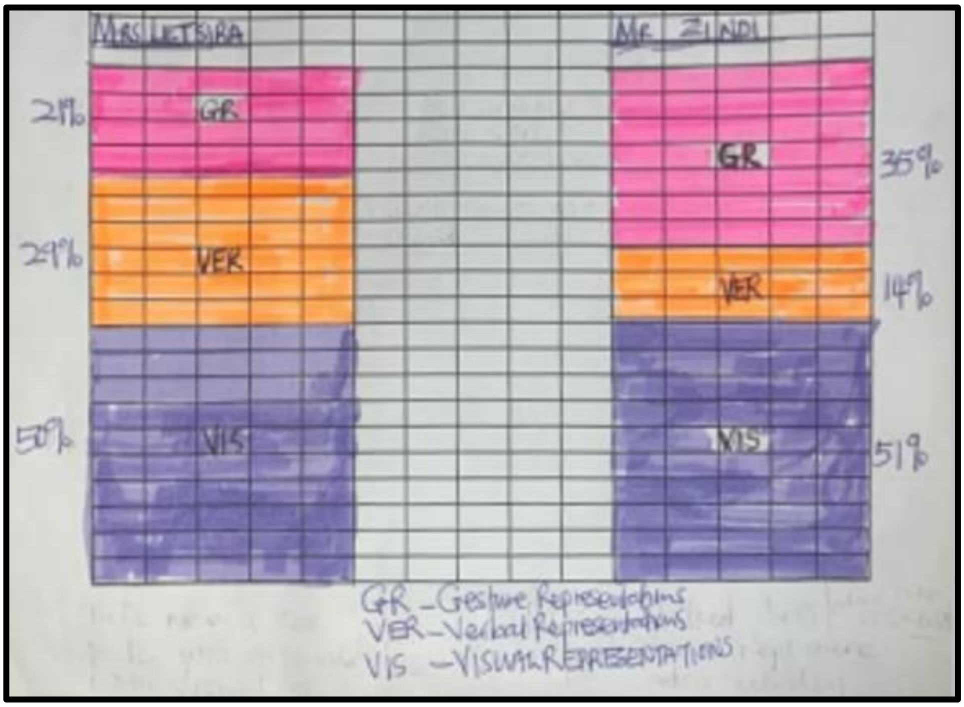

Figure 7. 10: Mrs. Letsiba's and Mr. Zindi's multimodal reprentations 'maps'
Where GR- gesture representations, VER- verbal representations, VIS- visual representations

7.7.1 Mrs. Durand's Discourse Strategy Profile

Considering Mrs. Durand's Discourse strategies 'Maps' (Figures. 7.5, 7.7 and 7.9) it stood out that her low frequency of **logical exposition** (LOG EXP) was compensated for by a high frequency of **foregrounding and backgrounding** (F/B). She thus, focused less on developing understanding and tried to relate the science in question to previous work. She personalised the concepts and called on previous learners' experiences with the concepts thus, trying to make her lessons learner-centred. This is evidenced by Mrs. Durand's use of a bit of **Logical exposition** and **foregrounding and backgrounding** (LOG EXP + F/B). In this case, Mrs. Durand drew the logic of understanding from **logical exposition** as well as **foregrounding and backgrounding** on what the learners had learned before. Hence, as an assessment-focused teacher, Mrs. Durand was interested in structuring the logic of the subject. The Discourse strategies 'map' on thematic development strategies reveals that Mrs Durand depended on external authority to structure the logic in the subject. In particular, she drew on the course textbook and Gregor Mendel's narrative to consolidate the logic in the subject as evidenced by her infrequent use of **Logical exposition** coupled with **Narrative** and **External Text Dialogue** (LOG EXP + NARR + ETD).

Mrs. Durand's practice seemed to be diverse and was also associated with the use of **teacher questioning series** (TQS) to consolidate the logic in the subject. However, the type of questions she asked her learners were simple questions or incomplete statements that were completed by learners. Consequently, there was no evidence of the **reducing difficulty** strategy as evidenced by Mrs. Durand's social strategies 'maps'. These questions or statements were paused using **eliciting moves** discussed in Chapter 6. Overall, to structure the logic in the subject, Mrs. Durand also used multimodal representations in concert viz, **gesture representation**s (GR), **verbal representations** (VER), and **visual representations** (VIS) as shown by the multimodal representations 'maps'(see Figure 7.9). Furthermore, analysis of Mrs. Durand's social strategies 'map' shows that in Mrs. Durand's classroom **controlling pacing** was used as a pedagogical measure together with **signalling boundaries** (CP + SB) to cover the curriculum. Furthermore, **interrupting learners**, **admonition** and **marking importance** (IL+ADM + MI) were used to maintain the structure of the activities during the lessons.

7.7.2 Mr. Zulu's Discourse Strategy Profile

According to Mr. Zulu's Discourse strategy 'maps' (Figures. 7.5, 7.7 and 7.9) it stood out that Mr. Zulu developed concepts together with his learners through **teacher question series** and consolidating through **logical exposition** (TQS + LOG EXP). Thus, for Mr. Zulu conceptual development was expressed in his classroom dialogue while consolidation was expressed in his monologues making his lessons teacher-centred. Furthermore, Mr. Zulu's Discourse strategies 'maps' reveal that he aimed for conceptual understanding through the use of **logical exposition** and **signalling boundaries** together (LOG EXP + SB). In other words, he used LOG EXP + SB together as he pushed conceptual development or the development of concepts with his learners. For Mr. Zulu, logic was expressed in **marking new or old information** (MN/O). For Mr Zulu, TQS was associated with **building moves** where the teacher paused questions requiring reasoning, justification, or clarification. Thus, in Mr. Zulu's classroom, the **teacher question series** was associated with the **reducing difficulty** strategy (TQS + RD). Consequently, this study uncovered the following.

TQS + RD = CONCEPTUAL DEVELOPMENT FOCUS

In Mr. Zulu's classroom, **external text dialogue** (ETD) replaced the **teacher question series** when he was going over classwork or homework. Unlike Mrs Durand and Mrs. Letsiba, Mr Zulu, did not draw on the textbook to consolidate the content for assessment but to consolidate conceptual understanding. Further, in Mr. Zulu's classroom, **duolog** replaced **teacher question series** when he was consolidating understanding of concepts in individual learners unlike in

Mrs. Durand's classroom where **duolo**g replaced **teacher question series** when the teacher and learners were discussing non-subject matter issues or consolidating curriculum logic in the subject. Thus, for Mr. Zulu, the course textbook was not important for building conceptual understanding. In general, Mr. Zulu focused on conceptual development using multimodal representations (GR, VER, and VIS). Nonetheless, analysis of Mr. Zulu's multimodal representations 'map' shows that he used fewer **verbal representations**.

7.7.3 Mrs Letsiba's Discourse Strategy Profile

Analysis of Mrs. Letsiba's Discourse strategies 'maps' (Figures. 7.6, 7.8 and 7.10) shows that Letsiba used **logical exposition** (LOG EXP) for logical extension of the content to show the coherence of the curriculum for assessment. Like Mrs. Durand, Mrs, Letsiba was interested in structuring the logic of the subject. She depended on external authority to structure the logic as evidenced by her massive use of **external text dialogue**. Like Mrs. Durand, Mrs Letsiba, drew on the course textbook to consolidate the logic in the subject as evidenced by her use of LOG EXP + ETD. Mrs. Letsiba also drew the logic of understanding the coherence of the curriculum from what learners learned before as evidenced by her use of **logical exposition** and **foregrounding and backgrounding** (LOG EXP + F/B). Since there was less focus on developing understanding in Mrs. Letsiba's classroom, there was more use of **getting personal** and **being funny** (GP + BF) as the teacher tried to relate the science to the learner's experiences. This reveals that like Mrs Durand, Mrs. Letsiba tried to make her lessons learner-centred. In addition to less development of concepts, Mrs. Letsiba justified the curriculum through the use of **selective summary** (SEL SUM), where she focused mostly on definitions of terms. Unlike Mrs. Durand, the **teacher questioning series** (TQS) was scarce in Mrs. Letsiba's classroom. In a few instances where it was evident, the questions were simple or consisted of incomplete statements that were simply completed by the learners. Hence, there was no evidence of **reducing difficulty** (RD) in Mrs. Letsiba's practice, which is also true for Mrs. Durand discussed earlier. Overall, this study has revealed Mrs. Letsiba and Mrs. Durand to be assessment-focused since their practices were associated with LOG EXP + F/B + ETD. Thus, the discussion above uncovered the following.

LOG EXP + F/B + ETD = ASSESSMENT FOCUS

Analysis of Mrs. Letsiba's Multimodal representation 'maps', shows that like Mrs. Durand, Mrs. Letsiba used **gesture representations** in collaboration with few **verbal representations**, and few **visual representations.**

7.7.4 Mr. Zindi’s Discourse Strategy Profile

Analysis of Mr. Zindi’s Discourse strategies ‘maps’ (Figures. 7.6, 7.8 and 7.10) revealed Mr. Zindi as building conceptual understanding through **logical exposition** and consolidating through **teacher question series** (LOG EXP + TQS) making his practice teacher-centred. In particular, after building conceptual understanding himself without involving learners, Mr. Zindi checked understanding through consolidation using a **teacher question series**. For instance, he would give his learners an activity at the end of each conceptual development, a practice which was more intense in Mr. Zulu’s classroom. Thus, for Mr. Zindi, conceptual development was expressed in the teacher monologues while consolidation was expressed in the classroom dialogue. Like Mr. Zulu, Mr Zindi’s **teacher question series** was associated with **building moves** requiring reasoning, justification, and clarification. Thus, his **teacher question series** was associated with **reducing difficulty** (TQS + RD = CONCEPTUAL DEVELOPMENT FOCUS), where he tried to paraphrase his questions to meet his learners' level of understanding, a strategy that was absent in both Mrs. Durand’s and Mrs. Letsiba’s practice. When focusing on conceptual development, Mr. Zindi, used multimodal representations. However, Mr, Zindi’s multimodal representations ‘maps’ like Mr. Zulu’s show that Mr. Zindi used fewer verbal representations than Mrs. Durand and Mrs. Letsiba.

Though Mr. Zindi and Mr. Zulu differed in the way they were building concepts in their classrooms, it is striking to note that the study revealed both of them as being conceptual development-focused. It is interesting to note that this CONCEPTUAL DEVELOPMENT STRATEGY like the ASSESSMENT FOCUSED STRATEGY was associated with multimodal representations viz, **gesture representations** (GR), **verbal representations** (VR), and **visual representations** (VR) that were used in concert. However, Mrs. Durand’s and Mrs. Letsiba’s practices were associated with more **verbal representations** than Mr. Zulu's and Mr. Zindi's.

7.8 Summary of key findings in relation to emergent teacher strategies extracted from the teaching of basic genetics

Reverting to the research question: ***What kinds of emergent teacher strategies can be extracted from the Discourse of teaching basic genetics to grade 12 learners?***

7.8.1 Emerging Discourse Teaching Strategy Model

The four teachers' Discourse strategies profiles uncovered two types of teachers viz, the one who is conceptually focused, and the other one who is assessment focused. In this study, I classified Mr. Zulu and Mr. Zindi as conceptually focused teachers whose interest was developing conceptual understanding. To build conceptual understanding in their learners, both teachers used a type of **teacher questioning series** which I refer to as TQS1 in this study. This type of **teacher question series** (TQS1) was associated with a strategy known as **reducing difficulty** (RD) and **building moves** (reasoning, justification, and clarification). After building conceptual understanding these teachers could use **logical exposition** (LOG EXP**)** for consolidation. However, the sequence of events was not fixed as the process of building conceptual understanding would involve swapping around the TQS1 and LOG EXP. This means that the teacher would build conceptual understanding using **logical exposition** (LOG EXP**)** and use t**eacher question series** (TQS1) for consolidation. In both teachers' practices, TQS1 was replaced by **external text dialogue** which I refer to as ETD1 (linked to RD) when they drew on the course textbook for questions as they were going over classwork or homework. In addition, during the building and consolidation processes, both teachers used less **verbal** than **visual** and **gesture representations**.

In this study, Mrs. Durand, and Mrs. Letsiba were portrayed as assessment-focused teachers whose focus was on structuring the logic or coherence in the subject. To structure the logic in the subject, both teachers used **logical exposition** while drawing on external authority through **external text dialogue** which I refer to as ETD2. Both teachers personalised their teaching as they called on previous work and learners' experiences as evidenced by their extensive use of **foregrounding and backgrounding.** The type of **teacher question series** (TQS2) evident in Mrs. Durand's and Mrs. Letsiba's classrooms was associated with simple questions or consisted of incomplete statements that were simply completed by the learners. This type of **teacher question series** is associated with **eliciting moves** hence, there was no evidence of **reducing difficulty** (RD) in both practices. The **logical exposition** was sometimes replaced by **selective summary** where the teachers justified the curriculum. In Mrs. Durand's and Mrs. Letsiba's practice, **controlling pacing**, and **marking importance** were used as pedagogical measures together with **admonition** for discipline. To structure the logic in the subject in their classrooms, Mrs. Durand and Mrs. Letsiba used more **verbal**, less **visual** and **gesture representations**.

This chapter sought to answer the following sub-research questions. ***What kinds of emergent teacher strategies can be extracted from the Discourse of teaching basic genetics to grade 12 learners?*** Based on the four teachers' Discourse profiles and the two types of teachers that were uncovered in this study, I developed a Discourse Teaching Strategy Model which I discuss in the next section

7.8.2 The Discourse Teaching Strategy Model

The Discourse Teaching Strategy Model (Figure 7.11) shows that the teacher's strategy during teaching can either be conceptual development-focused or assessment focused. On the one hand, a teacher who adopts the Conceptual Development Strategy builds conceptual understanding in his/her learners using mainly the **teacher question series** which I refer to as TQS1 which is associated with **reducing difficulty** (RD). To enhance conceptual understanding in his/her learners this teacher associates TQS1 with **building moves** (reasoning, justification, and clarification). This teacher can use the **external text dialogue 1** (ETD1) as he/she draws on the course textbook or past examination question papers to build conceptual understanding. This ETD1 is also associated with **reducing difficulty**. The conceptually focused teacher uses **logical exposition** (LOG EXP) in monologues for consolidation as he/she **signals boundaries** and **marks old/new information**. However, the use of TQS1 and LOG EXP may be swapped around in terms of building conceptual understanding and consolidation. To build conceptual understanding and **logical exposition**, **teacher question series 1** and **external text dialogue 1** are used in conjunction with less **verbal representations** and more **visual** and **gesture representations**.

On the other hand, a teacher who is assessment-focused adopts the assessment-focused strategy during teaching. This teacher's interest in learners getting marks in tests and examinations hence, there is less emphasis on building conceptual understanding. So, this teacher structures the logic of the subject in monologues using **logical exposition** (LOG EXP), **selective summary** (SEL SUM) as well as **foregrounding and backgrounding** (FB). As the teacher uses these monologue strategies, he/she draws on external authority to structure the logic in the subject through **external text dialogue 2** (ETD2) as they read from the course textbook. Furthermore, since strategies like foregrounding and backgrounding as well as selective summary call on previous work and learner's experience, the content may end up (**getting personal)** (GP). Figure 7.11 further shows that the assessment-focused strategy is characterised by **teacher question series 2** (TQS2) which is associated with simple questions that may be incomplete statements that are completed by learners. These questions are also associated with **eliciting moves** thus, do not require **reducing difficulty** (RD). **Marking importance** and **controlling pacing** are used as pedagogical measures together with the **admonition** for disciplining the learners. Finally, the process of structuring the logic in the subject is associated with more use of verbal representationsand less visual and gesture representations.

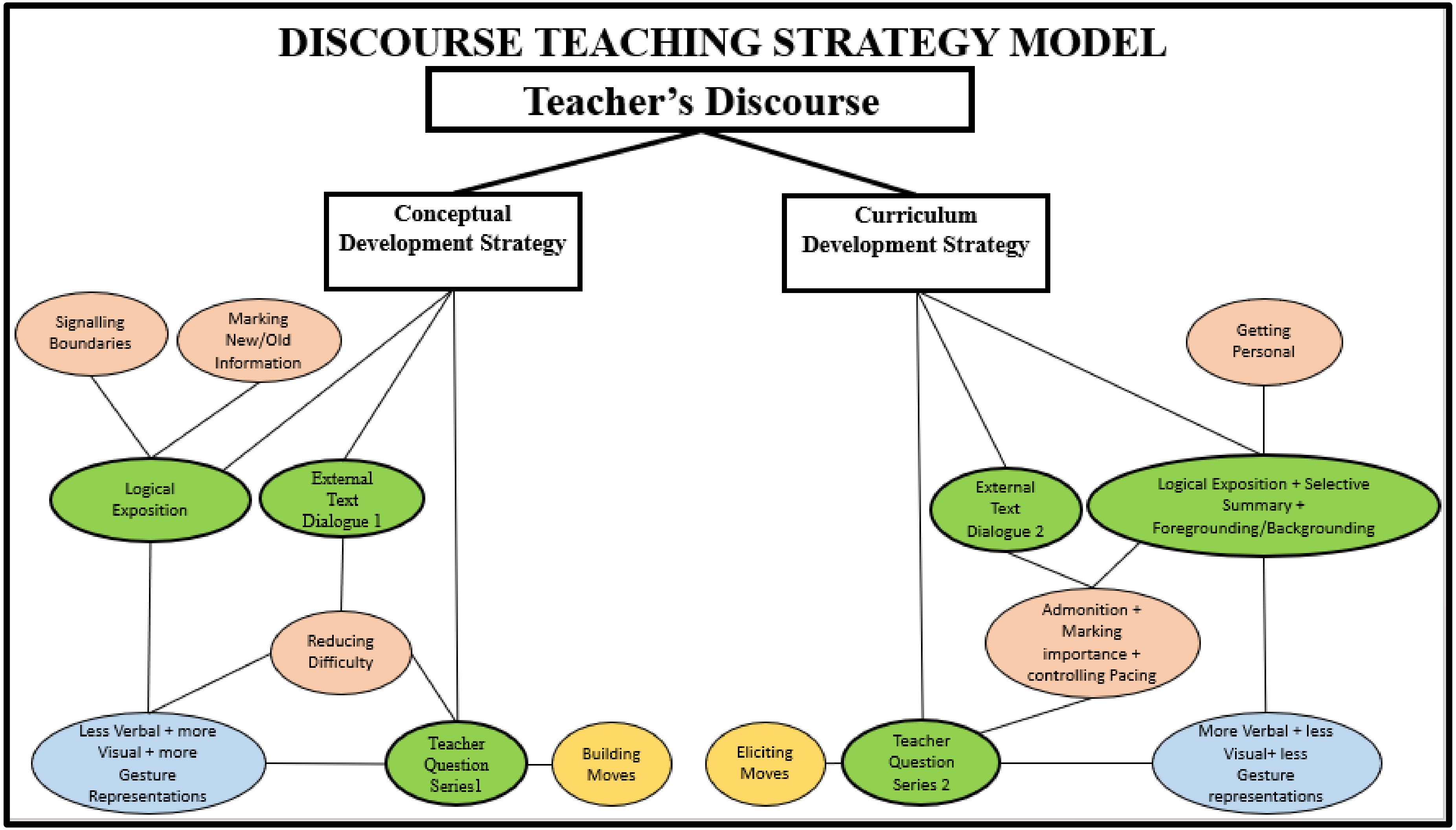

Figure 7. 11: My Discourse Teaching Strategy Model

7.8.3 The extended version of the Discourse Teaching Strategy Model

The Discourse Teaching Strategy Model (Figure 7.11) discussed above was developed from the teachers' Discourse strategies that were analysed in this chapter based on my third sub-research question. In this section, I present an extended version of the Discourse Teaching Strategy model (Figure 7.12) based on the analysis that I conducted on the four teachers' thematics (Chapter 5), patterns of interaction and teacher Discourse moves (Chapter 6) and teachers' Discourse strategy profiles (Chapter 7). These chapters were informed by my three sub-research questions.

Figure 7.12 shows that conceptually focused teachers whose interest is in developing conceptual understanding construct more Joint Thematics (JT) than Teacher Thematics (TT) and Joint external text Thematics (JET). These thematics are associated with the construction of Process/Target, Identified/Identifier, Item/Elaboration, Process/Target, Action/Motivation, Attribute/Carrier, Agent/Process, Definition, Classifier/Thing semantic relations. However, the Item/Elaboration semantic relation seems to be linked to the other relations constructed where it is used for clarifying meanings of terms and providing examples. To build the semantic relations discussed above, both teachers used a type of **teacher questioning series** which I refer to as TQS1 in this study. This type of **teacher question series** (TQS1) was associated with a strategy known as **reducing difficulty** (RD) and **building moves** (reasoning, justification, and clarification). In conceptually focused teachers' classrooms the use of TQS1 occurs during authoritative interactions with some dialogic interactions where the Discourse patterns are I-R-P-R-P open or closed chains. These chains are associated with open-ended questions and **building moves** which ask learners for clarification and reasons or justification for their responses.

After building conceptual understanding conceptually focused teachers use **logical exposition** (LOG EXP**)** for consolidation which constitutes fewer cases of non-interactive authoritative Discourse. However, the sequence of events is not fixed as the process of building conceptual understanding may involve swapping around the TQS1 and LOG EXP. This means that the teacher would build conceptual understanding using **logical exposition** (LOG EXP**)** and use t**eacher question series** (TQS1) for consolidation. In conceptually focused teachers' practices, TQS1 can be replaced by **external text dialogue** which I refer to as ETD1 (linked to RD) when they draw on the course textbook for questions when they are going over classwork or homework. On being asked about the reasoning behind consolidation, Mr. Zindi who was one of the conceptually focused teachers had this to say. "*Some may have understood, some may have understood but there could be some who do not even know what they do not know. Right! Some learners sit there, you teach them they walk out but they do not know what they actually do not know, or they do not know. So, you should give them classwork or homework, you are now consolidating.* For conceptually focused teachers, logic is expressed in **signalling boundaries** and **marking new or old information** (MN/O). In addition, during the conceptual building and consolidation processes, these teachers use fewer **verbal** than **visual** and **gesture representations**.

Figure 7.12 also shows that assessment focused teachers whose interest is in structuring the logic in the subject for examination purposes so that learners get marks in tests and examinations. To develop science concepts, these teachers construct more Teacher Thematics (TT) than Joint Thematics (JT) and Teacher External text Thematics (TET). Like the conceptually focused teachers, the assessment focused teachers also construct Process/Target, Identified/Identifier, Item/Elaboration, Process/Target, Action/Motivation, Attribute/Carrier, Agent/Process, Definition, Classifier/Thing. However, Item/Elaboration is used less frequently in assessment focused teachers' classrooms and is not linked to the other types of semantic relations. Instead, the Definition semantic relation seems to be constructed more frequently than others. To construct the semantic relations above, assessment focused teachers use **logical exposition** while drawing on external authority through **external text dialogue** which I refer to as ETD2. These teachers personalise their teaching as they call on previous work as evidenced by their extensive use of **foregrounding and backgrounding.** The **logical exposition** as well as **foregrounding and backgrounding** of concepts as the teachers construct semantic relations or thematic patterns occurs in non-interactive classrooms that were characterised by authoritative with a bit of dialogic Discourse. In few cases of dialogue, assessment focused teachers' classrooms are associated with a type of **teacher question series** (TQS2) which is associated with simple questions or incomplete statements that are simply completed by the learners. This type of **teacher question series** was associated with **eliciting moves** hence, there is no evidence of **reducing difficulty** (RD) in these teachers' practices. The **logical exposition** is sometimes replaced by **selective summary** where the teachers justify the curriculum. In conceptually focused teachers' practice, **controlling pacing**, and **marking importance** are used as pedagogical measures together with **admonition** for maintaining discipline. Furthermore, to structure the logic in the subject in their classrooms, assessment focused teachers use more **verbal**, fewer **visual** and **gesture representation**

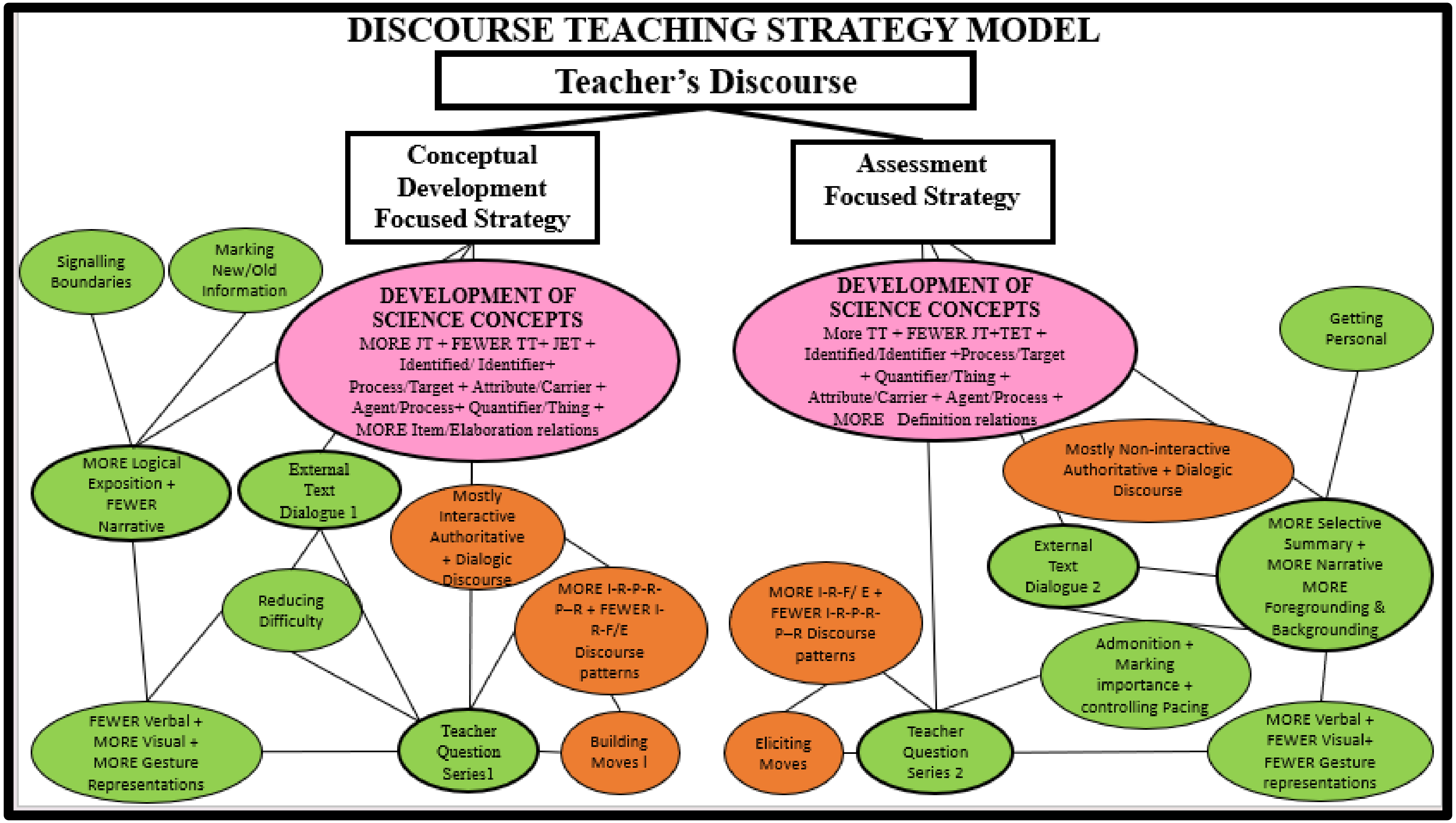

Figure 7. 12: The Extended Discourse Teaching Strategy Model

Where JT- Joint Thematics, TT- Teacher Thematics, JET- Joint External text Thematics, TET-Teacher External text Thematics, I- Initiation, R- Response, P- Prompt, F- Follow-up, and E- Evaluation

7.9 Chapter Summary

In this chapter, I presented findings based on my third research question presented above in terms of the three categories viz, thematic development strategies, social strategies, and multimodal representations. This was followed by teacher Discourse profiles and ultimately the emerging Discourse strategies in the form of a model. In the next chapter, I will present the discussion of my findings, conclusions, and recommendations.

CHAPTER 8: DISCUSSION OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

8.0 Introduction

Genetics is perceived as one of the most difficult topics in biology (Fauzi et al., 2021). What compounds this matter is the fact that teachers are also identified as contributing to poor performance as they are said to be lacking confidence in genetics (DBE, 2021b). Among other factors, language has been identified as a key factor contributing to this poor performance (Maremane et al., 2022). However, this study was not considering issues of multilingualism or monolingualism instead my focus was on the language of science. Thus, this study focused on teachers' use of the language of science while teaching basic genetics to grade 12 learners in their classrooms. The main objective of this study was to characterise the teachers' Discourse when teaching basic genetics concepts in South African classrooms. In Chapter 5, I illustrated, through the creation and identification of Thematics, how teachers developed genetics concepts during the teaching of basic genetics to grade 12 learners. I did this by focusing on the Thematic items used, how they were used to build semantic relations, and subsequently the construction of Thematic patterns. In Chapter 6, I demonstrated the patterns of interaction that were evident in terms of communicative approach, patterns of Discourse, and teacher Discourse moves. In particular, I focused on how teachers directed their science talk during the teaching of genetics concepts using one or more communicative approaches through a variety of teacher Discourse moves. Finally, in Chapter 7, I analysed the Discourse strategies that the teachers used to negotiate meaning-making of genetics concepts with their learners and generated a new model which I refer to as the Discourse Teaching Strategy Model. Generally, analysis for the three findings chapters was influenced by the theoretical framework that I developed in Chapter 2 presented in Figure 2.3.

Thus, in this chapter, I present a simplified version of the Discourse Teaching Strategy Model which I developed in Chapter 7. I then use this model to answer my three sub-research questions which is followed by a synthesis of these answers in order to answer the main research question. After this, I present limitations of the study which is followed by the conclusion and recommendations for various interest groups. Lastly, I raise some issues that still need further research. In the next section, I present a resumé of what the study consisted of.

8.1 Resumé

This study was motivated by poor performance and poor quality of passes in life sciences in South Africa at grade 12 (DBE, 2021b). This poor performance has been blamed on many factors including teachers. The aim of this study was to characterise the teachers' Discourse during the teaching of basic genetics to grade 12 learners. In this study, my conception of Discourse was influenced by Gee's Theory of Discourse which makes a distinction between Discourse with an upper-case 'D' denoting language and other factors associated with it and discourse with a lower-case 'd' as referring to language. Therefore, in this study, the teachers' Discourse 'D' was conceptualised in terms of language 'd' (the language of science) and context which entailed Discourse strategies, interaction patterns, teacher Discourse moves and multimodal representations. This study drew on literature and research from the fields of Discourse analysis, language, teacher talk, science teaching, classroom Discourse and important life sciences curriculum documents (CAPS, Examination Guidelines and ATP) in order to develop a complex picture of classroom. A qualitative case study was conducted in three high schools in Johannesburg in the province Gauteng of South Africa where four teachers were observed three times, and video recorded while teaching basic genetics concepts to grade 12 learners. A follow-up interview was conducted with each teacher. These post observation interviews together with field notes were used for data triangulation purposes. The lesson observation transcripts were analysed using Lemke's Thematic Analysis merged with Mortimer and Scott's Communicative Approaches, Discourse patterns and teacher interventions which I refer to as teacher Discourse moves in my study. The new knowledge developed by this study is the model which I refer to as the Discourse Strategy Teaching Model and what I observed between the Discourse of the CAPS Curriculum Statement and the Discourse of the Examinations guidelines. In the next section, I revisit the analytical framework and the research questions.

8.2 Revisiting the Analytical Framework and the sub-research questions

This study was conducted in South Africa, a country that has consistently ranked last or close to the bottom in worldwide TIMMS studies on the quality of performance in mathematics and science (Mullis et al., 2020). This performance portrays a negative picture of the quality of learner performance produced by South African teachers in these subjects. The South African National Diagnostic Report (2022) on grade 12 performance attests to this poor performance and argues that the quality of passes in life sciences at the grade 12 level is low. The unfamiliar understanding of the language of science is believed to be one of the factors contributing to the low performance in science in South Africa (Mavuru & Ramnarain, 2020). This performance inthe language of science cannot be used in isolation from its context of use, a notion that Gee (2017) refers to as Discourse. Therefore, this study chose Discourse as a focus on the teachers when teaching basic genetics concepts in South African classrooms. This study was primarily influenced by Gee's theory of Discourse which makes a distinction between Discourse with a big 'D' denoting language and other factors (context). Thus, analysis was done by exploring how the teachers used the science language in their contexts. To analyze the teachers' Discourse, I merged Lemke's Thematic analysis (Lemke, 1990) and Mortimer and Scott's four classes Communicative Approach and Patterns of Discourse (Scott et al., 2011) as shown in the theoretical framework presented in Chapter 2 in Figure 2.3.

The main question that guided my research was "*What characterises the teachers' Discourse when teaching basic genetics concepts in South African classrooms.* This question was broken down into three sub-research questions as follows:

- How do teachers develop genetics concepts during the teaching of basic genetics to grade 12 learners?
- What forms of interaction patterns and teacher Discourse moves are evident during the teaching of basic genetics to grade 12 learners?
- What kinds of emergent teacher strategies can be extracted from the Discourse of teaching basic genetics to grade 12 learners?

To address these sub-research questions, I adopted a socio-cultural view of learning and acknowledged the role of the teacher in creating opportunities for meaning making through the use of a variety of strategies as they develop science concepts during teaching and the importance of social interactions to achieve shared understandings. This study was conducted in a grade 12 context which is influenced by the three curriculum documents (CAPS, Examination Guidelines and ATP among others. Hence, to place my findings in context, I present a reflection on CAPS, Examination Guidelines, and ATP documents as well as their influence on teacher practice in the next section.

8.3 Reflection on the CAPS document and Examination Guidelines and their influence on teacher practice

As alluded to earlier in Chapter 5, grade 12 life sciences teachers are presented with various documents including the National Curriculum Statement (NCS) Curriculum and Assessment Policy Statement (CAPS) the Examination Guidelines and ATP. These documents were analysed in Section 5.2. In this section, I present my reflection on these documents.

The discourse ('d') analysis conducted on the CAPS document versus the Examination Guidelines shows that the discourse or the language that is used in the Examination Guidelines is completely different from the way the CAPS document is phrased which may imply reality versus vision. On the one hand, the CAPS document uses the discourse of the language of learning and is very specific about what learners are expected to do and also links the current concepts to those that the learner has done before. When introducing a strand, the CAPS document uses the discourse of learning such as explore, establish links, understand, research, expose learners, enabling learners terms and concepts. On the other hand, the Examination Guidelines document uses the discourse (language) of examinations, for instance when introducing a topic such as meiosis, it indicates the paper in which the topic will be examined and the marks that the topic constitutes in that paper. Furthermore, when listing down the concepts to be dealt with, the Examination Guidelines use the language (discourse) of examinations such as *define*, and *differentiate*.

Though the Examination guidelines document should be used in conjunction with the CAPS document for life sciences, it is probable that grade 12 Life Sciences teachers use the Examination Guidelines only when teaching in a bid to drill and prepare their learners for the final examination since schools and teachers are rated based on their grade 12 pass rates (Munsamy, 2014). It is, therefore, not surprising that the Discourse emerging from this study seems to be generally influenced by the Examination guidelines rather than the CAPS document. Next, I present the simplified version of my Discourse Teaching Strategy Model. .

8.4 My Discourse Teaching Strategy Model

The Discourse Teaching Strategy Model identifies two type of strategies viz, conceptual development focused strategy and assessment focused assessment. The model is based on five aspects which focus on the role of the teacher in developing the scientific concepts and supporting learners in meaning-making. The five aspects are development of concepts, communicative approach, patterns of Discourse, teacher Discourse moves and teacher Discourse strategies which are shown in Figure 8.1. This is a model that can be used to identify a particular teacher's Discourse practices.

Conceptual focused strategy

Figure 8.1 shows the *conceptual focused strategy* which I discuss now (the italicised words are used in the model). The classrooms of the teachers adopting this strategy are characterised by a larger proportion of *co-constructed thematics* where the teachers involve their learners in the development of concepts and a smaller proportion of *joint external text thematics* where the teachers together with their learners work on questions written in a course textbook or past exam papers. In addition, these teachers' classrooms are characterised by a smaller proportion of *teacher thematics* where the teachers develop science concepts on their own without asking for learner participation. Thus, most of the time conceptually focused teachers involve their learners in the development of the concepts thus providing them opportunities to learn using the science concepts. The conceptual development focused strategy is associated with construction of more *Item/Elaboration semantic relations* where teachers introduce learners to new science concepts which they further elaborate on by clarifying and providing examples for their learners to understand.

Figure 8.1 further shows that to develop science concepts, the teacher adopting the *conceptual development focused strategy* use *higher order questions* associated with a Discourse strategy known as *reducing difficulty* and *teacher Discourse moves* known as *building moves (*reasoning, clarification, or justification). Owing to their nature, *higher order questions* sometimes warrant that teachers paraphrase the questions for the learners to understand. In conceptual development focused teachers' classrooms, the use of *higher order questions* associated with *building moves* occurs during *authoritative and dialogic interactions* where the *patterns of Discourse* are *longer interactions*.

Figure 8.1 shows that teachers adopting the *conceptual focused strategy* use *logical exposition*. After building conceptual understanding through the use of *higher order questions* these teachers would use *logical exposition* for consolidation. This would constitute fewer cases of *non-interactive authoritative Discourse* in these teachers' classrooms as shown in the model. However, the sequence of events is not fixed as the process of building conceptual understanding can be swoped around. This means that to build conceptual understanding the teacher can use *logical exposition* and then use *higher order questions* for consolidation. When using higher order questions, conceptually focused teachers may use questions in text where they draw on the course textbook for questions when they were going over classwork or homework. For these teachers logic is expressed in *signalling boundaries* and *marking new* or *old information*. In addition, during conceptual building and consolidation processes, teachers using conceptual focused strategy use fewer *verbal* than *visual* and *gesture representations*.

Assessment focused strategy

Figure 8.1 shows the assessment focused strategy which I discuss now (the italicised words are used in the model). Teachers adopting this strategy are interested in structuring the logic in the subject for examination purposes. These teachers construct more *teacher thematics* than *co-constructed thematics* and *teacher external text thematics*. Unlike *conceptual development focused* teachers, *Item/Elaboration* is used less frequently assessment focused teachers' classrooms. Instead, the *definition semantic relation* seem to be constructed more frequently than others. To construct the semantic relations, assessment focused teachers use *logical exposition* while drawing on *definitions in text* from the course textbook. These teachers personalise their teaching as they call on previous work as evidenced by their extensive use of *foregrounding and backgrounding* shown in the model. Figure 8.1 further shows that *Logical exposition* as well as *foregrounding and backgrounding* of concepts as the teachers construct semantic relations or occurs in *non-interactive* classrooms that are characterised by *authoritative* with a bit of *dialogic Discourse*. In few cases of dialogue, assessment focused classrooms are characterised by with *lower order questions* associated with simple questions or statements that were simply completed by the learners. These result in patterns of Discourse that are characterised by shorter interactions. The *lower order questions* are associated with *eliciting moves* hence, there is no evidence of a strategy called *reducing difficulty* in these teachers' practices. In addition, Figure 8.1 shows that *logical exposition* is sometimes replaced by *selective summary* where the teachers justify the curriculum. Teachers adopting the conceptual focused strategy use *controlling pacing* and *marking importance* as pedagogical measures together with *admonition* for maintaining discipline. To structure the logic in the subject in their classrooms, assessment focused use more *verbal*, fewer *visual* and *gesture representations*.

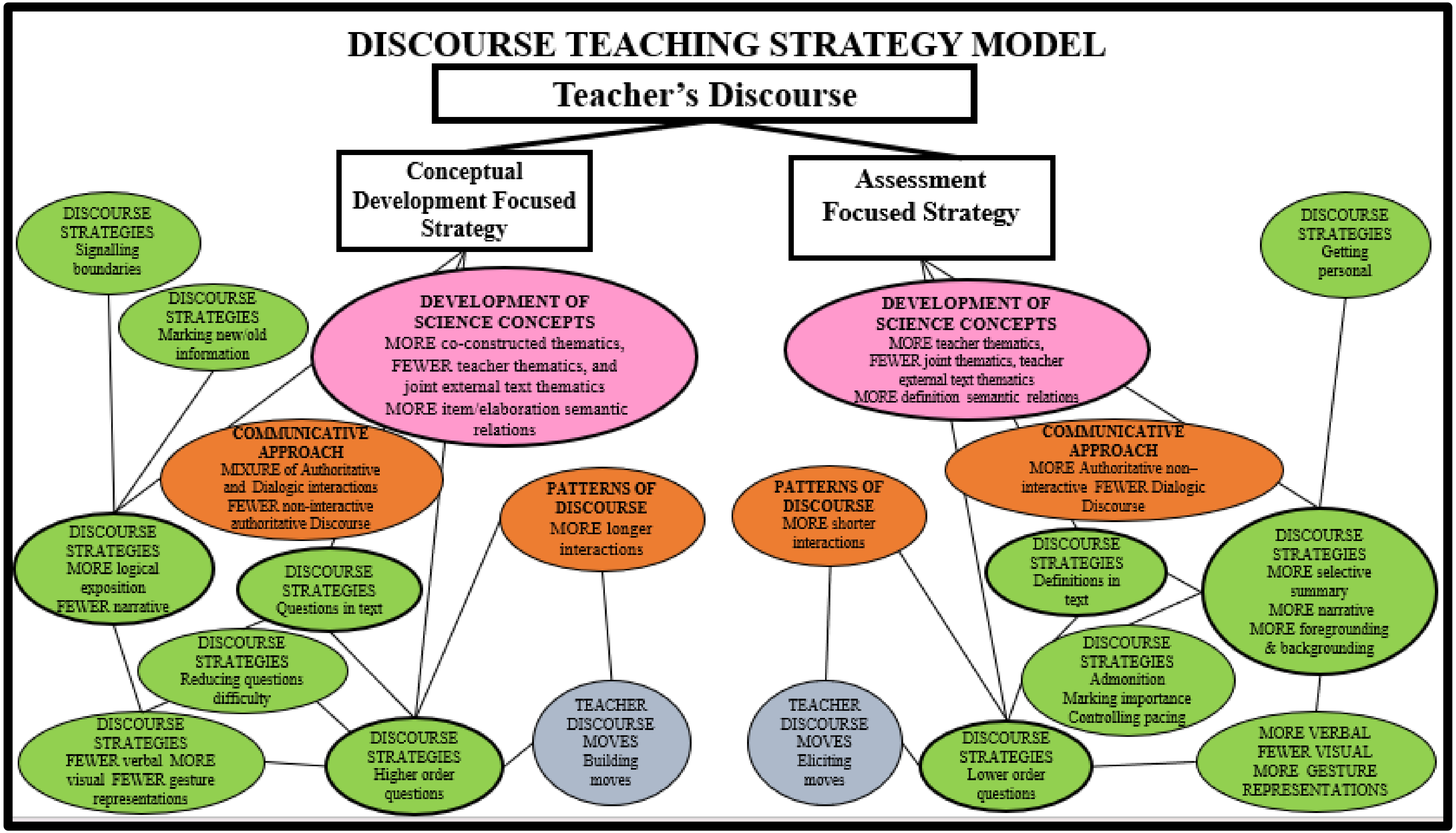

Figure 8. 1: The Discourse Teaching Strategy Model

8.5 Answering my sub-research questions

In this section, I use the Discourse Teaching Strategy model (Figure 8.1) developed in this study to answer my sub-research questions. I make use of the two overarching strategies to characterise the teachers' Discourse unveiled by this study. I do this by comparing the two strategies in terms of the five aspects presented by the model which are development of concepts, communicative approach, patterns of Discourse, teacher Discourse moves and teacher Discourse strategies.

8.5.1 Sub-research Question 1

How do teachers develop genetics concepts during the teaching of basic genetics to grade 12 learners?

The Discourse of the teachers gave me insight into these two ways of looking at things. The answer is, some were conceptually focused, and the others were assessment focused. On the one hand, Figure 8.1 shows that during development of genetics the conceptually focused teachers co-constructed thematics together with their learners and elaborated more on new concepts. on the other hand, Figure 8.1 shows that assessment focused teachers constructed more teacher thematics than constructed ones and that there were more definition of terms during the development of thematics than elaboration of concepts.

8.5.2 Sub-research Question 2

What forms of interaction patterns and teacher Discourse moves are evident during the teaching of basic genetics to grade 12 learners?

The answer is some were engaged in more dialogic interactions with longer interactions while others engaged in more non-interactive authoritative Discourse with shorter interactions. Figure 8.1 shows that the teachers who were conceptually focused engaged in more dialogic interactions which were associated with patterns of Discourse that were characterised by more longer interactions and building teacher Discourse moves. Figure 8.1 further shows that those teachers who were assessment focused engaged in more non-interactive authoritative Discourse associated with patterns of Discourse patterns characterised by shorter interactions and eliciting teacher Discourse moves.

8.5.3 Sub-research Question 3

What kinds of emergent teacher strategies can be extracted from the Discourse of teaching basic genetics to grade 12 learners?

The answer is two kinds of strategies emerged from the teachers' Discourse which are conceptually focused strategy and assessment focused strategy. Figure 8.1 shows that the conceptual focused strategy is associated with higher order questions which is linked to a strategy known as reducing difficulty. These higher-order questions were also associated with questions in a text. In addition, Figure 8.1 shows that the conceptual focused strategy is associated with more logical exposition fewer narratives, more visual than gesture and verbal representations. furthermore, Figure 8.1 shows that the conceptual focused strategy is associated with signalling boundaries and marking new/old information which were used to express logic in the content. In the next section, I present the overall discourse emerging from this study.

8.6 Overall teachers' Discourse emerging from this study

This study was guided by the following main research question; ***What characterises the teachers' Discourse when teaching basic genetics in South African classrooms?***

The new knowledge in this study is the Discourse teaching strategy model and the differences that I observed between the discourse in the CAPS curriculum statement and the discourse in the examination guidelines. The Department of Basic Education and the entire political fraternity insist on the passing of National Senior Certificate Examinations as a sign of a school's efficiency or quality (Munsamy, 2014). This has impacted the overall Discourse evidenced in the science classrooms in this study. Owing to this, teachers in this study teachers generally adopted an exam-oriented Discourse. However, two types of Discourse emerged from this study viz, assessment-focused Discourse and conceptual development-focused Discourse. With assessment-focused Discourse, the teachers focused more on learners getting marks and passing examinations than learning the actual Biology (Bigozzi et al., 2018). Probably, the teachers who adopted this type of Discourse in this study were influenced by the Examination Guidelines for Life Sciences discussed earlier in Section 25. This Discourse is associated with teachers encouraging learners to memorise information rather than comprehending its application in real-life situations which hinders the development of higher-order cognitive skills (Yasmin et al., 2023). This is supported by Fadhlullah and Ahmad (2017) who argue that assessment oriented teaching encourages rote learning and regurgitation of information resulting in limited opportunities for creative and analytical thinking. The other two teachers were influenced by the Examination Guidelines to a lesser extent and thus, focused on the conceptual development during the teaching of genetics. Therefore, the type of Discourse that emerged from these two teachers' classrooms was conceptual development Discourse. This Discourse was characterised by teaching for understanding the definitions, rules, and principles in a field of study as well as their relationships (VanScoy, 2019). This type of Discourse increases the acquisition of knowledge through meaningful learning rather than rote learning (Tofade et al., 2013) thus promoting conceptual understanding of genetics concepts (Bigozzi et al., 2018)

In terms of interaction patterns, the general type of teacher Discourse that emerged from this study when dealing with basic genetics concepts was authoritative Discourse. This finding supports (Esra & Hüseyin, 2018) who found that teachers mainly used authoritative Discourse when they examined interaction and Discourse in the teaching and learning of senior phase natural science. This is also consistent with the findings obtained by (Scott & Ametller, 2007) who found the dominant Discourse used during interactions to be authoritative. In this study, the teachers mostly used the authoritative approaches for either presenting the scientific story to their learners directly (authoritative noninteractive) or initiating short or open/closed interactions with learners to get the correct answers and end the interaction (authoritative interactive). As observed in many science classrooms, the teachers' main objective is to elicit the correct answer from their learners and then close the interaction (Kaya et al., 2016). This resonates with Khoza and Msimanga (2021) who conducted a study which showed that the facilitation of interaction by science teachers bears a resemblance of an interest in learners' correct answers rather than providing learners with opportunities to learn. The pattern of Discourse employed during these interactions was I-R-P-R-P/E cycle. This finding is inconsistent with Kaya et al. (2016) who found that interactions in classrooms progressed with the domination of teachers using a triadic (I-R-E/F) Discourse pattern. This finding resonates with Gharbavi and Iravani (2014) who investigated teacher talk in the classroom interactions and found that the talk followed the IRF sequence and concluded that this routine may supress the most vibrant and enthusiastic learners. Nonetheless, the chain Discourse pattern provides learners with opportunities to learn as they engage in discussions, and reflective thinking (Msimanga, 2021). In this study these chain Discourse patterns were sustained by teacher Discourse moves such as eliciting and building moves. These moves have the potential to move classroom interactions beyond the I-R-E/F triad (Tytler & Aranda, 2015).

Lastly in this study, to develop genetics concepts, conceptual development focused teachers in their authoritative interactive Discourse employed higher order questions while assessment focused teachers used lower order question. According to Tofade et al. (2013) higher order questions evoke deeper and analytical thinking hence, teachers are encouraged to ask such questions. On the one hand, conceptual development focused teachers in their interactive Discourse used a type of questions in text associated with drawing on the course textbook for questions during revision of classwork. This allows learners to understand and gain capacities to use information to improve their work (Otnes & Solheim, 2019), and enhance self-regulation (Meusen-Beekman et al., 2016). Hence, this practice with questions help learners to sharpen their skills and teachers to diagnose their learners' conceptual understanding. On the other hand, assessment focused teachers lacked this type of Discourse, but their definitions in text were associated with drawing on the course textbook for definitions which is associated with rote learning (Tofade et al., 2013). In the absence of dialogue, all four classrooms were characterised with the telling Discourse where the teachers provided their learners with information. Numerous communicative teachers regard the telling Discourse as an obstacle that limits learners' learning opportunities (Gharbavi & Iravani, 2014). However, when fused with the narrative strategy, the telling Discourse may enhance increased comprehension, interest, and engagement (Dahlstrom, 2014). In this study, both authoritative interactive Discourse and the telling Discourse was associated with the use of multimodal representations (visual verbal and gestures). In life sciences, more than one representational form is usually used to convey information and support knowledge construction (Treagust & Tsui, 2013) Consequently several well-established theories allege that the use of multimodal representations increases learners' opportunities to learn (Opfermann et al., 2017). Thus, the teachers in this study created opportunities to learn through the use of multimodal representations. In the next section, I present limitations of this study.

8.7 Limitations of the study

In this study, there were several potential threats to the validity of the research. Much of this research is descriptive, where the main validity threat is that of incomplete or inaccurate data (Lai, 2021). Nonetheless, this was largely resolved by the extensive use of video recordings, transcriptions of observed lessons, field notes, and interview audio recordings. These formed a permanent record and point of reference. As discussed about the use of videotaping of lessons, reactivity of both the teachers and learners in classroom based research is a real problem (Praetorius et al., 2017). Teachers preparing 'show lessons' rather than teaching in an 'everyday' mode is one aspect. More problematic is the possibility that teachers and learners might feel nervous and behave unnaturally. Hence, one can consider these observed lessons as the teachers' 'best practice'. Mr. Zulu attested to this effect during his interview session where he said that having another professional made him feel nervous but soon got used to it. Researchers using video data suggest that teachers' practice is fairly resistant to change and that the presence of a researcher and video camera is unlikely to change their practice markedly (Blikstad-Balas, 2017).

Generalisability refers to the extent to which the findings from one's study can be applied to other contexts (Smith, 2018). Case studies analyse small groups or individuals in particular contexts. In this case, generalisability would be impossible since a small group or one person is not representative of the larger population (Makel et al., 2022). This study was restricted to four participants who were teaching life sciences to grade 12 learners at three Johannesburg High Schools in South Africa. Therefore, these four teachers were not representative of the larger population of grade 12 life sciences teachers in South Africa. Nonetheless, when conducting research involving case studies, researchers usually assume that their findings will be transferrable thus, they consider transferability of their findings rather than generalisability (Weise et al., 2020). According to (Makel et al., 2022) in case studies transferability provides readers with the option of applying qualitative findings to their contexts. To transfer the research findings to their situations, readers must be supplied with as much detail as possible about the research situation (Smith, 2018). Thus, in this study, the descriptive context about the sample, data collection and analysis provided in Chapter 3 can furnish life sciences teachers and researchers with a premise for comparing with their classrooms in their contexts. In the next section, I present conclusion and Recommendations.

8.8 Conclusion and Recommendations

8.8.1 Conclusion

This study was conducted in South Africa, a nation that has consistently ranked last or close to the bottom when it comes to worldwide studies on the quality of mathematics and science (Mullis et al., 2020). This performance portrays a negative picture about the quality of learners produced by South African teachers in these subjects. The South African National Diagnostic Report (2018) on grade 12 performance attests to this notion as it argues that the quality of passes in life sciences at matric is low. What compounds this matter is the fact that teachers are also identified as contributing to the poor performance as they are said to be lacking confidence in topic genetics (National Diagnostic report, 2018). Thus, the question of what characterises the teachers' Discourse when teaching basic genetics concepts in South African classrooms is one that is central to redress the existing status quo in the South African education system. What is of particular interest is that the findings in this study has unveiled two types of Discourse viz, the one that portrays a conceptually focused teacher and the other one that portrays a assessment focused teacher.

On the one hand, the conceptually focused teacher's Discourse was characterised by more Joint Thematics, fewer Teacher Thematics and Eternal Text Thematics which was related to revision of either homework of classwork. This type of teacher constructed more Item/Elaboration. When constructing semantic relations, the conceptually focused teacher's Discourse was also characterised by use of logical exposition in monologues which was associated with signalling boundaries and marking new/old information a higher order questions related to reducing difficulty and questions in text. The higher order questions were associated with open ended questions requiring reasoning, justification or clarification of learners' responses which are building moves (Ellis et al., 2019). In addition, lower order questions were also related to definitions in text where the teacher drew on the course textbook for questions during revision sessions of either classwork or homework. The social interaction strategies used by the conceptually focused teacher were used for expressing the logic in the concepts. All strategies discussed here were used in tandem with few verbal, more visual and more gesture representations. This teacher's classroom was characterised by authoritative interactions (though there were few shifts from authoritative to dialogic Discourse) many long interaction patterns.

On the other hand, the Discourse of an assessment-focused teacher was characterised by more teacher thematics, fewer co-constructed thematics and eternal text thematics where the teacher drew on the course textbook for definitions. This type of teacher constructed more Item/Elaboration relations than Definition relations as he/she consulted the course textbook. When constructing semantic relations, the assessment-focused teacher's Discourse was also characterised by low use of logical exposition, more selective summary or more foregrounding and backgrounding which was associated with social interaction strategies such as getting personal, admonition, marking importance, controlling pacing in monologues. These monologue strategies were related to lower-order questions where the teacher drew on the course textbook for the construction of semantic relations such as Definitions. The assessment-focused teacher was also characterised by lower-order questions which were associated with simple questions which required one-word answers. These simple questions were associated with eliciting types of moves. These strategies were used in concert with more verbal, few visual and few gesture representations. The assessment-focused classroom was characterised by authoritative non-interactions and very few shifts from authoritative to dialogic Discourse as well as shorter interaction patterns. This study has also shown textbooks to be perpetuating misconceptions for instance use of the term 'gene' as a synonym of the term 'allele' a finding which is consistent with literature (Thörne & Gericke, 2014a).

8.8.2 Recommendations to Teachers

Results from this unveiled two types of teachers viz are conceptually focused and assessment focused. Using these two teachers' profiles, I developed a teaching model which I refer to as The Discourse Teaching Strategy Model. It shows the various combinations of strategies that can be adopted by teachers depending on whether they are teaching for conceptual understanding or getting marks in tests or examinations. I emphasised that the Discourse Teaching Strategy Model is offered as a model for thinking about the planning and development of science teaching as well as a tool for reflection upon one's teaching strategies. Teachers can use the model for reflection for evaluation in terms of whether they would have taught their learners for conceptual understanding or getting marks in tests and examinations. Furthermore, teachers can use the Discourse Teaching Strategy Model for planning purposes to plan for the appropriate combinations of strategies depending on whether they are interested in developing conceptual understanding with their learners or getting marks. Thus, this model can be used to expand self-development or in-service development especially if one is to teach for conceptual understanding, characterising teachers' Discourse or as an analytical tool for analysing teachers' Discourse.

8.8.3 Recommendations to the Gauteng Department of Education (GDE)

District officials responsible for monitoring schools may consider drawing from my Discourse Teaching Strategy Model for in-service development especially if teachers are to teach for conceptual understanding. The Department of Education may also draw from this study by reconsidering the textbooks that they recommend for use as references in the schools since one was seen as perpetuating misconceptions.

8.8.4 Recommendations to Teacher Training Institutions

Teacher training institutions are encouraged to emphasise the use of the Discourse Teaching Strategy Model in their training programmes if they are to produce graduates who are interested in teaching their learners for conceptual understanding.

8.9 Future Research

My Thesis has focused on the teachers' Discourse during the teaching of genetics and developed a Discourse teaching Strategy Model. Further research would explore how the two Discourse strategies viz conceptual development strategy and assessment-focused strategy would affect the performance of learners in genetics.

Epilogue

Embarking on this academic journey, I envisaged other Life Sciences teachers being the beneficiaries of my study. Little did I know that I was also going to be part of the beneficiaries of my study. The two types of teachers that emerged from this study: conceptually focused and assessment focused are influencing my current practice as a Life Sciences educator teaching grade 12 learners. These two teachers are expected to assist in preparation of grade 12 learners for their National Senior Certificate Examination as learners are expected to conceptually master basic genetics. This finding has then led me to alternate from being a conceptually focused teacher to being an assessment focused one at times during my teaching. Ironically, I have turned out to be the biggest fan of my study.

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Appendices

Appendix A: Ethics Documents

APPENDIX A

Appendix A1: Ethics Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)
R14/49 Mupfawa

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: H19/07/43**
PROJECT TITLE	A discourse analysis of teachers' use of language when teaching basic genetics concepts in South African classrooms
INVESTIGATOR(S)	Mrs S Mupfawa
SCHOOL/DEPARTMENT	Education/
DATE CONSIDERED	19 July 2019
DECISION OF THE COMMITTEE	Approved
EXPIRY DATE	19 November 2022

DATE 20 November 2019 **CHAIRPERSON** (Professor J Knight)

cc: Supervisor : Prof M Rollnick, Prof K Padayachee and Prof A Buma

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 resubmit the protocol to the Committee. **I agree to completion of a yearly progress report.**

____
Signature

____/____/____
Date

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

Appendix A2: GDE Approval Letter

Appendix A3: Information Sheet for Teachers

PARTICIPANT INFORMATION SHEET: TEACHER

04/11/2019
Dear Teacher
My name is Shungu Mupfawa and I am a PhD student in the Faculty of Education at the University of the Witwatersrand in Johannesburg. As part of my studies, I have to undertake a research project, and I am investigating the following topic: ***An analysis of the teachers' Discourse when teaching basic genetics concepts in South African classrooms.*** This research project aims to find out the teachers' classroom Discourse when teaching genetics terminology in South African classrooms.

As part of this project, I would like to invite you to take part by allowing me to observe three of your normal lessons on genetics which will be 35-45 minutes. Can you also help me by participating in an interview which will be 20 minutes long? The interview will be conducted after school hours at a time and place that is convenient to you. With your permission, I would like to record the observations with a video-recorder and interview using an audio-recorder. In this study, I may not be in a position to conduct direct classroom observations for all teachers of interest since I will also be required to teach my own grade 12 learners at that particular time. Owing to this, video recording will be used. The video recordings will be stored in a password-protected computer,

You will not receive any direct benefits from participating in this research, and there are no disadvantages or penalties for not participating. You may withdraw at any time or not answer any question if you do not want to. The interview and observations will be completely confidential and anonymous as I will not be asking for your name or any identifying information, and the information you give to me will be held securely and not disclosed to anyone else. I will be using a pseudonym to represent your participation in my final research report. If you experience any distress or discomfort at any point in this process, we will stop the interview or resume another time.

If you have any questions during or afterwards about this research, feel free to contact me or my supervisor on the details listed below. This study will be written up as a research report which will be available online through the university library website. If you wish to receive a summary of this report, I will be happy to send it to you. If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email Shaun.Schoeman@wits.ac.za

Yours sincerely,
Shungu Mupfawa
Email: 744173@students.wits.ac.za
Cell: 0726339145
Supervisor's name: Prof. Marissa Rollnick
Email: marissarollnick@wits.ac.za Cell: 082 374 5528

Appendix A4: Information Sheet for Teachers

Appendix A5: Learner Consent Form

LEARNER CONSENT FORM

Title of project: *An analysis of the teachers' Discourse when teaching basic genetics concepts in South African classrooms*

Name of researcher: Shungu Mupfawa

I, …………………………….……………………………….., agree to participate in this research project. The research has been explained to me and I understand what my participation will involve.

Please circle the relevant options below.

I agree that my participation will remain private	**YES**	**NO**
I agree that the researcher may use anonymous quotes in his/her research report	**YES**	**NO**
I understand that the transcripts will be stored in a password protected computer	**YES**	**NO**

……………………………………………………………... (Signature of participant/learner)

………………………………………………………………. .. (Name of participant/learner)

……………………………………………………………… (Date)

Appendix A6: Learner Consent- Video recording

LEARNER CONSENT FORM: VIDEO RECORDING

Title of project: *An analysis of the teachers' Discourse when teaching basic genetics concepts in South African classrooms*

Name of researcher: Shungu Mupfawa

I, ……………………………………., agree to participate in this research project. The research has been explained to me and I understand what my participation will involve.

Please circle the relevant options below.

I agree that my participation will remain private	**YES**	**NO**
I agree that I may be video recorded during the classroom observations	**YES**	**NO**
I agree that the information on the video recordings may be used privately in the research report	**YES**	**NO**
I understand that the video recordings and transcripts will be stored in a password-protected computer	**YES**	**NO**

………………………………………………………………………..… (Signature of participant/learner)

………………………………………………………………………..… (Name of participant/learner)

………………………………………………………………………..… (Date)

Appendix A7: Teacher Consent Form

TEACHER CONSENT FORM

Title of project: *An analysis of the teachers' Discourse when teaching basic genetics concepts in South African classrooms*

Name of researcher: Shungu Mupfawa

I, ……………………………………………………………………., agree to participate in this research project. The research has been explained to me and I understand what my participation will involve.

Please circle the relevant options below.

I agree that my participation will remain anonymous	**YES**	**NO**
I agree that the researcher may use anonymous quotes in his/her research report	**YES**	**NO**
I agree that the interview may be audio recorded	**YES**	**NO**
I understand that the audio recordings and transcripts will be stored in a password-protected computer	**YES**	**NO**

……………………………………………………..……….. (Signature of participant)

…………………………………………………………........ (Name of participant)

…………………………………………………………........ (Date)

Appendix A8: Teacher Consent form -Video recording

TEACHER CONSENT FORM: VIDEO RECORDING

Title of project: *An analysis of the teachers' Discourse when teaching basic genetics concepts in South African classrooms*

Name of researcher: Shungu Mupfawa

I, ………………………………………………………, agree to participate in this research project. The research has been explained to me and I understand what my participation will involve.

Please circle the relevant options below.

I agree that my participation will remain anonymous	**YES**	**NO**
I agree that the lessons observed may be video recorded	**YES**	**NO**
I agree that the information on the video recordings may be used anonymously in the research report	**YES**	**NO**
I understand that the video recordings and transcripts will be stored in a password-protected computer	**YES**	**NO**

………………………………………………………………………… (Signature of participant)

………………………………………………………………………… (Name of participant)

………………………………………………………………………… (Date)

Appendix A9: Letter to the Principal

Appendix A10: Letter to the SGB Chair

Appendix A11: Assent Form

ASSENT FORM

I am Shungu Mupfawa and I am a PhD student in the Faculty of Education at the University of the Witwatersrand in Johannesburg. I am doing a study to figure out the kind of conversations that take place between teachers and learners during genetics lessons in South African classrooms. I am asking you to take part in the research study because your teacher recommended you for this project.

For this research, I would like to invite you to take part by allowing me to video record you as I observe three of your teacher's normal lessons on genetics which will be 35-45 minutes. I will keep all your participation and the video recordings private. The video recordings will be stored in a password protected computer.

You will not receive any direct benefits from participating in this research, and there are no disadvantages for not participating. I do not think that any big problems will happen to you as part of this study. You do not have to be in this study if you do not want to. You won't get into any trouble with the University of Witwatersrand, your teacher, or your school if you say no. You may stop being in the study at any time or request not to be video recorded. The lesson observations will be private as I will not be asking for your name and the information on the video recordings will be held securely and not disclosed to anyone else. I will be using a false name to represent your participation in my final research report.

Your parents/guardians were asked if it is OK for you to be in this study. Even if they say it's OK, it is still your choice whether or not to take part. You can ask any questions you have, now or later. If you think of a question later, you or your parents can contact me on cell: 072 633 9145, email: 744173@students.wits.ac.za or my supervisor: Prof. Marissa Rollnick on cell: 082 374 5528, email: marissarollnick@wits.ac.za. If you have any complaints about the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email Shaun.Schoeman@wits.ac.za.

Sign this form only if you:

- have understood what you will be doing for this study,
- have had all your questions answered,
- have talked to your parent(s)/legal guardian about this project, and
- agree to take part in this research
- agree to be video recorded

____

Your Signature (Participant) | Printed Name | Date

____

Researcher explaining study

Signature | Printed Name | Date

Appendix A12: Parent Information Sheet- English

PARTICIPANT INFORMATION SHEET ENGLISH: PARENT

23/10/2019

Dear Sir / Madam

My name is Shungu Mupfawa and I am a PhD student in the Faculty of Education at the University of the Witwatersrand in Johannesburg. As part of my studies, I have to undertake a research project, and I am investigating the following topic: ***An analysis of the teachers' Discourse when teaching basic genetics concepts in South African classrooms.*** This research project aims to find out the teachers' classroom Discourse when teaching genetics terminology in South African classrooms.

As part of this project, I was wondering whether you would mind if I invited your child or ward to participate in three lesson observations on genetics. These lessons will be 35-45 minutes long. With your permission, I would like to record the observations with a video recorder. In this study, video recording will be used because I may not be in a position to conduct direct classroom observations for all teachers or all classes of interest. As a matric life sciences teacher, I will also be required to teach my own grade 12 learners at that particular time. The video recordings will be stored in a password protected computer.

Your child/ward will not receive any direct benefits from participating in this research, and there are no disadvantages for not participating. Your child /ward may withdraw at any time or not answer any question if he/she does not want to. The observations will be completely confidential and anonymous as I will not be asking for your child's/ward's name or any identifying information. The information your child/ward will give to me will be held securely and not disclosed to anyone else. I will be using a pseudonym (false name) to represent your child's/ward's participation in my final research report.

If you have any questions during or afterwards about this research, feel free to contact me or my supervisor on the details listed below. This study will be written up as a research report which will be available online through the university library website. If you wish to receive a summary of this report, I will be happy to send it to you. If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email Shaun.Schoeman@wits.ac.za

Yours sincerely,

Shungu Mupfawa

Email: 744173@students.wits.ac.za

Cell: 0726339145

Supervisor's name: Prof. Marissa Rollnick

Email: marissarollnick@wits.ac.za Cell: 082 374 5528

Appendix A13: Parent Consent Form- English

PARENT CONSENT FORM ENGLISH

Title of project: *An analysis of the teachers' Discourse when teaching basic genetics concepts in South African classrooms*

Name of researcher: Shungu Mupfawa

I, …………………………………………….……………. agree that my child/ward may participate in this research project. The research has been explained to me and I understand what my child's/ward's participation will involve.

Please circle the relevant options below.

I agree that my child's/ward's participation will remain anonymous	**YES**	**NO**
I agree that the researcher may use my child's/ward's anonymous quotes in his/her research report	**YES**	**NO**
I understand that the transcripts will be stored in a password protected computer	**YES**	**NO**

……………………………………………………………………………….... (Signature of parent)

……………………………………………………………………………….... (Name of parent)

……………………………………………………………………………… (Date)

Appendix A14: Parent Consent Form- Video recording-English

PARENT CONSENT FORM: VIDEO RECORDING

Title of project: *An analysis of the teachers' Discourse when teaching basic genetics concepts in South African classrooms*

Name of researcher: Shungu Mupfawa

I, ……………………………………., agree that my child/ward may participate in this research project. The research has been explained to me and I understand what my child's/ward's participation will involve.

Please circle the relevant options below.

I agree that my child's/ward's participation will remain anonymous	**YES**	**NO**
I agree that my child/ward may be video recorded during the classroom observations	**YES**	**NO**
I understand that the video recordings and transcripts will be stored in a password-protected computer	**YES**	**NO**

……………………………………………………………………………………..….. (Signature of parent)

……………………………………………………………………………….… (Name of parent)

……………………………………………………………………………….… (Date)

<u>Appendix A15: Parent Information Sheet -IsiZulu</u>

<u>Appendix A16: Parent Consent Form- IsiZulu</u>

<u>Appendix A17: Parent Consent Form- Video recording- IsiZulu</u>

<u>Appendix A18: Parent Information Sheet- Sesotho</u>

<u>Appendix A19: Parent Consent Form -Sesotho</u>

<u>Appendix A20: Parent Consent Form -Video recording-Sesotho</u>

<u>Appendix A21: School's letter of permission</u>

Appendix B: Interview Schedule and Transcripts

<u>Appendix B1: Teacher Interview Schedule</u>

<u>Appendix B2: Mrs. Durand Interview Transcript</u>

<u>Appendix B3: Mrs. Letsiba Full Interview Transcript</u>

Appendix B3.1: Part of Mrs. Letsiba Interview Transcript

Full Interview Transcript for Mrs Letsiba School B (60.9 minutes)
18/08/2020
(On-line interview)
Transcription conventions

Symbol	Signification
T:	A verbal contribution belonging the teacher
L:	A verbal contribution belonging to any individual learner
Ls:	A verbal contribution belonging to two or more learners
…	Noticeable pause of less than 1 second in a turn, which could be due to reformulation or hesitation
—	Sound abruptly cut off e.g. false start Truncated word Formal made shorter e.g. S-
/ /	Words between slashes show uncertain transcription (not clearly known or understood.
/ ? /	Inaudible utterances
[ ]	Words in brackets indicate non-linguistic information eg [pause for 1 second] Laughter, throat clearing, smile, applause, sigh happily/ warily/deeply, contently, swallowing, nodding, shaking head dance or movement towards/away
( )	Parenthesis around tone units indicate words spoken in a sotto voice under one's breath (in a very quiet voice)
,	Slight pause
?	High rising intonation
.	Falling intonation at the end of tone unit
:	Colon following a vowel, indicates elongated vowel sound or extending length of sound e.g Die:d
::	Extra colon indicates longer elongation
↑	A step up in pitch/ high pitch (high quality sound)
↓	A shift down in pitch (low quality sound)
^	A caret indicating high pitch level e.g. ^weird
-	Low pitch level
— —	Self-interruption or repair
abc	Best guess transcription
ALL CAPS	Utterance is louder/said with extra stress/emphasised compared with surrounding words
/	Rise tone e.g. …saying something, /
\	Fall tone
V	Fall-rise-tone
Λ	Rise-fall-tone
CAPS	Prominent syllable e.g. sOn or FAthEr

1.	R:	After watching your videos, how did you feel?
2.	Mrs Letsiba:	[Laughter]
3.	R:	[Laughter]
4.	Mrs Letsiba:	Aah… oh… [Laughter] Ehm… ehh… I had mixed ehh… feelings, but anyway ehh… I was happy… even the kids, wanted that ehh… video.
5.		That ehh… ma'am can…
6.	R:	Ehm.
7.	Mrs Letsiba:	Can you ehh…send the video to us because it will keep on reminding them.
8.		And what I have realised is that whenever I am teaching them ehh… these kids have their phones on, and they are taking ehh… videos.
9.		Ehh… I am happy about it.
10.	R:	Oh, that is good!
11.		Would you mind telling me more about yourself in terms of your teaching experience?
12.	Mrs Letsiba:	We are starting afresh?
13.		Okay, ehm… I started teaching a long time ago uch… in 1995 in the Limpopo province teaching life sciences.
14.		So, life sciences has become my bread and butter.
15.	R:	Ehm.
16.	Mrs Letsiba:	And moving to Gauteng province, I then continued with my teaching of life sciences.
17.	R:	Ehm.
18.	Mrs Letsiba:	And yah… life sciences has just become something that I have to live with each, and every day and I am enjoying the subject.
19.	R:	Ehm.
20.	Mrs Letsiba:	Teaching the subject though sometimes… sometimes these kids, do not go with your pace.
21.		You understand, but I am a proud life sciences teacher.
22.	R:	Yah… can you tell me more about your… your marking experience as well as your previous year's ehh… grade 12 pass rate?
23.	Mrs Letsiba:	Okay, ehh… it was only in 2019 where my pass rate just ehh…went down at 79%.
24.	R:	Ehm.
25.	Mrs Letsiba:	Each and every year my pass rate percentage ranges from 80 to 90% ehh… / ? /
26.		What is wrong?
27.		Can you hear me?
28.	R:	Yes! It looks like something is wrong.
29.		I have muted my video, maybe you can mute your video as well.
30.	Mrs Letsiba:	No! It is fine… / ? / so, I have now marked NSC exams for many years.
31.		Again, from marking centre I am able to / ? /to use ehh… the experience / ? / see how many people / ? / other educators on how to do marking so far.
32.		And then in terms of being a teacher moderator, moderating all schools ehh…
33.		The problem is as much as we are / ? /…you understand?
34.	R:	Yes!

35. Mrs Letsiba: For me marking is also important.
36. That is why whenever I am marking, I want to be sure of each and every aspect.
37. R: Yah… perfect!
38. So how many grade 12 classes are you teaching?
39. Mrs Letsiba: Ehh… at the present moment due to COVID-19, I have ehh… six classes that I am teaching now.
40. R: Ehm… okay, how many learners in each class?
41. Mrs Letsiba: We have ehh… 20 per class.
42. Mrs Letsiba.: Do you think this is a good number for your teaching strategies?
43. T: Yes! It is a very good number even when ehh… / ? /.
44. Even now those that are not working are exposed, you understand.
45. R: Ehh… Yah.
46. Mrs Letsiba: To say that okay and then ehh… I think that also / ? / in terms of ehh… but then you know… each… each and every day.
47. I know that I am talking to a few people that will understand.
48. R: Ehm.
49. Mrs Letsiba: That will understand and / ? / you understand!
50. R: Ehm.
51. Mrs Letsiba: Then you are able to do what… to give extra work, you understand.

52. R: Ehm.

53. Mrs Letsiba: You understand, unlike when they are 48 in a class, sometimes they do not even listen

54. R: Ehm.

55. Mrs Letsiba: Now / ? / I appreciate…I can work the whole day but at the end of the day, I will achieve.

56. R: Yah…so, what assumptions do you make before ehh-- what assumptions do you make about your learners before you start teaching them genetics?

57. Mrs Letsiba: You know, we… we are coming from different families neh!

58. R: Ehm…

59. Mrs Letsiba: You understand, because some of them they… neh… [silence, inaudible] you understand!

60. R: Ehm.

61. Mrs Letsiba: Let us say for example paternity testing…

62. R: Ehm.

3

63.	Mrs Letsiba:	The other learners will say that but ma'am… I am not staying with my biological mom and I am not staying with my biological father neh…
64.	R:	Ehm.
65.	Mrs Letsiba:	…and sometimes or there are examples where they are given ehh… in a case where a child has been raped, you find that ehh… there is a child like that in the class.
66.		What I do is… I am very careful in terms of that.
67.		I do not have to hurt but isn't it… they have to know ehh… the concepts of genetics?
68.	R:	Ehm…okay, ehh… considering that you are life sciences teacher, what have been your experiences with genetics aah… with the genetics topic and associated terminology?
69.	Mrs Letsiba:	Yoh ma'am…ahh…that one ma'am / ? / neh…
70.	R:	Ehm.
71.	Mrs Letsiba:	…because ehh… / ? / before you can even start, you say this is of paramount importance that they acclimatise, I am teaching them to… acclimatise to what… ehh… those ehh… biological terminology… genetical ehh…genetics terminology.
72.		So, that before we can even start with ehh… the concept they already know when we are talking of ehh… the pheno… we are talking about geno…
73.		They already know because we have to… be… ehh-- genetics becomes ehh… ehh… the first ehh… topic.
74.	R:	Ehm.
75.	Mrs Letsiba:	They are not / ? / genetics
76.	R:	Ehm… okay.
77.	Mrs Letsiba:	Even though you try to give practical examples neh…
78.	R:	Ehm.

79.	Mrs Letsiba:	… but you find that in terms of teaching them, our children, because they have this thing of saying that genetics is difficult, ehh… yah…difficult ehh… topic.
80.	R:	Okay.
81.	Mrs Letsiba:	/ ? / So, you just have to give them… more activities.
82.	R:	Yah…
83.	Mrs Letsiba:	Give them ehh… more activities.
84.	R:	Ehm.
85.	Mrs Letsiba:	Ehh… just for them to ehh… understand, they find it difficult.
86.	R:	Ehm…so, considering that you are very…very much experienced in teaching life sciences.
87.		Have you changed your teaching approaches, ahh… with regards to terminology over time?
88.	R:	Ehm.
89.	Mrs Letsiba:	… for them to do what… ehh… I do define them…
90.	R:	Ehm
91.	Mrs Letsiba:	… you understand, and I am giving them … it is not about me always ehh… being in front of them… ehh… these children…
92.	R:	Ehm.
93.	Mrs Letsiba:	…ach!
94.	R:	Ehm.
95.	Mrs Letsiba:	So, I am forcing them to do what… ehh… to… go and read by doing what…
96.	R:	Yah…
97.	Mrs Letsiba:	I am giving them topics to say that ehh… you John, tomorrow you are going to tell [the class] what… what you understand about this

Appendix B4: Mr. Zindi Interview Transcript

Appendix B5: Mr. Zulu Interview Transcript

Appendix C: Observation Tool and Transcripts

Appendix C1: Classroom observation tool

Appendix C2: Mrs. Durand Lesson Observation Full Transcript

Appendix C2.1: Example of an episode from Mrs. Durand' LO1 Transcript

Full lesson transcript for Mrs. Durand of school A

Lesson 1: Meiosis on 11 February 2020.

Details

- This lesson transcript represents 35 minutes teaching time.
- A South African female white teacher was teaching the topic meiosis 60 male and female learner participants, all in grade 12 (two grade 12 classes combined).
- The lesson took place at a former model C co-educational High School in Johannesburg East district in Gauteng on 11 February 2020.
- When used by the teacher, the learners' names have been changed to protect anonymity.
- The textbook utilised during the lesson is Understanding Life Sciences Grade 12 Learner's book published by Pulse Education Services.
- Coloured markers and white board.

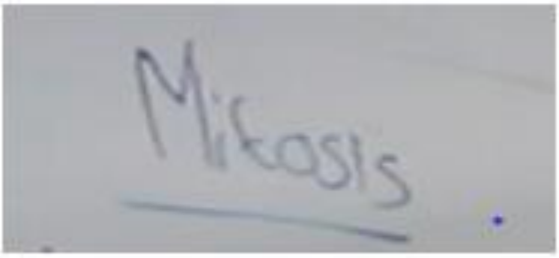
Transcription conventions

Symbol	Signification
T:	A verbal contribution belonging the teacher
L:	A verbal contribution belonging to any individual learner
Ls:	A verbal contribution belonging to two or more learners
…	Noticeable pause of less than 1 second in a turn, which could be due to reformulation or hesitation
–	Sound abruptly cut off e.g false start Truncated word Formal made shorter e.g S-

/ /	Words between slashes show uncertain transcription (not clearly known or understood.
/ ? /	Inaudible utterances
[ ]	Words in brackets indicate non-linguistic information eg [pause for 1 second] Laughter, throat clearing, smile, applause, sigh happily/ werily/deeply, contently, swallowing, nodding, shaking head dance or movement towards/away
( )	Parenthesis around tone units indicate words spoken in a sotto voice under one's breath (in a very quiet voice)
,	Slight pause
?	High rising intonation
.	Falling intonation at the end of tone unit
:	Colon following a vowel, indicates elongated vowel sound or extending length of sound e.g Die:d
::	Extra colon indicates longer elongation
↑	A step up in pitch/ high pitch (high quality sound)
↓	A shift down in pitch (low quality sound)
^	A caret indicating high pitch level e.g ^weird
-	Low pitch level

EPISODE 3: RECAPPING MITOSIS

14. ALRIGHT…What do we know about mitosis? \



15. What is MITOSIS…? \

16. Ls: Cell division

17. Mrs. Durand: YES, its cell division, what type of cell division…? \ [raising her left hand pointing to the word '*mitosis*' written on the board]

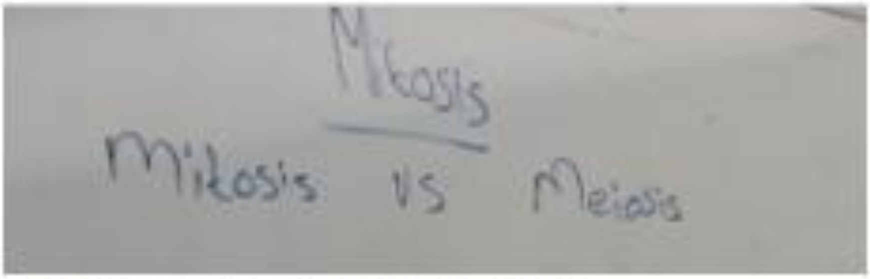
18. Joyce: /Inaudible/

19. Mrs. Durand: Aah…aah…this is the cell division that takes place where? [Showing them her open hands]

20. All over your body.

21. What do we call it? [Going to the white board]

22. Okay, now [writing on the white board '*mitosis vs meiosis*'] first…I am going to DO... something like this…because in grade 10, we sort of introduced very briefly, meiosis\



…thse essence of what meiosis is going to be about…

…so, you are supposed to now refer…

to your grade 10 terminology.

23. Remember, what I have said to you guys,

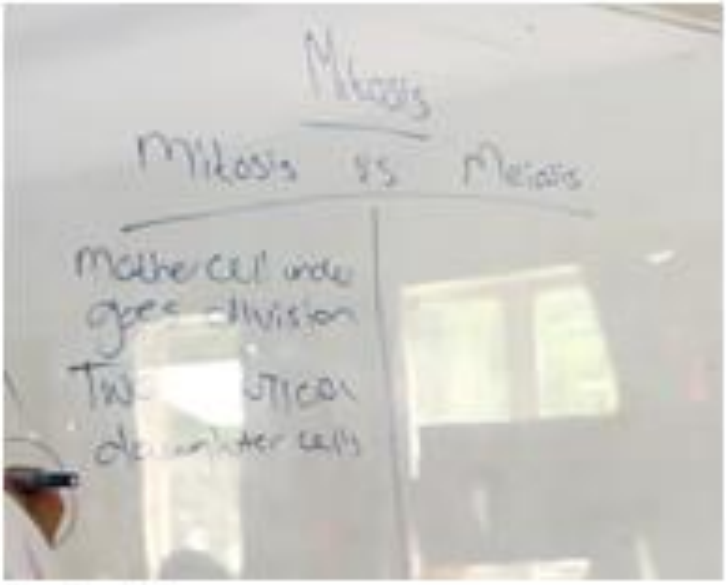
my class especially…/inaudible/…one follows the other one, so we are referring to grade 10.

24. [Referring to the board] Okay we are going to look at mitosis vs meiosis.

EPISODE 4A: MITOSIS

25. What is MITOSIS? [Pointing to the learners]

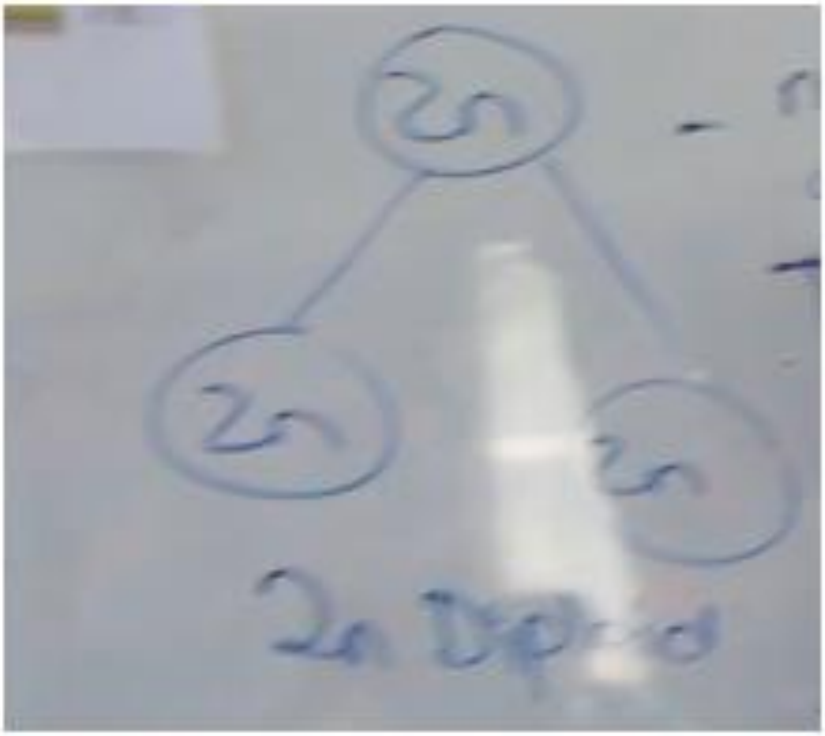
26. [Writing on the board] It is a cell division where the mother cell undergoes (pause) division.



28. Ls: Two identical—

29. Mrs. Durand: Now there is a term that we spoke about in grade 10…where we say two identical daughter cells.

30. In other words, if I do mitosis like this… [writing on the board]



…alrigHT and anybody still remember what this refers to? [Silence]

31. Okay, the chromosome number still stays the same here hey. [Silence] [writing on the board]

32. In other words when we said in mitosis...

...the chromosome number stays the same in these two identical daughter cells.

33. We refer to this as, being a diploid chromosome number.

34. FULL NUMBER OF CHROMOSOME...

does not change. \

35. Okay the chromosome number does not change, WHETHER you are human or dog.\ ...and it is in your body cells, what cells are body cells...? [pointing to the learners with marker]

9

36. [Silence] SOmatic cells ↑people [pause as she writes on the board].

37. It occurs in the somatic cells, [writing on the board] in other words... the cells all over your body [using hands]

...EXCEPT in YOUR [pause] sex cells\ [using hands]

10

38. ↑OKAY [pointing to the board]

…so, remember that…okay, it stays diploid.

39. Two identical daughter ↑CELLS identical to the parent cell.

11

Appendix C3: Mrs. Durand Lesson Observation 2 transcript

Appendix C4: Mrs. Durand Lesson Observation 3 transcript

Appendix C5: Mrs. Letsiba Lesson Observation 1 transcript

Appendix C6: Mrs. Letsiba Lesson Observation 2 transcript

Appendix C7: Mrs. Letsiba Lesson Observation 3 transcript

Appendix C8: Mr. Zindi Lesson Observation 1 transcript

Appendix C9: Mr. Zindi Lesson Observation 2 transcript

Appendix C10: Mr. Zindi Lesson Observation 3 transcript

Appendix C11: Mr. Zulu Lesson Observation 1 transcript

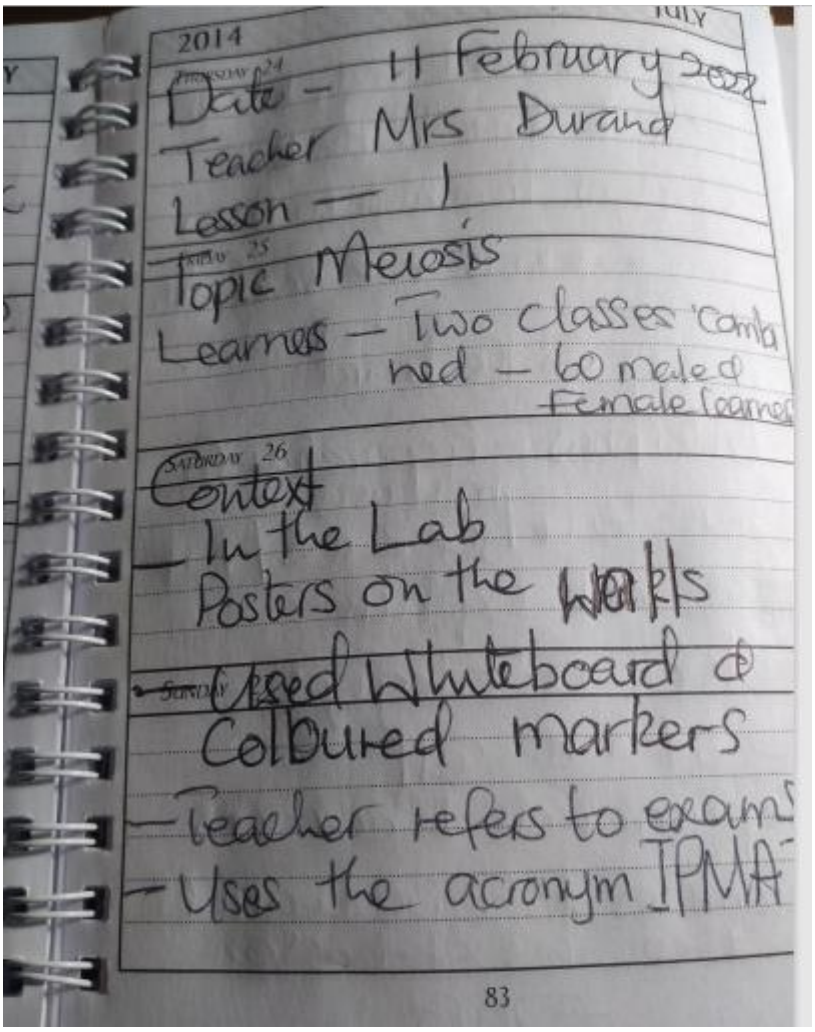
Appendix C12: Mr. Zulu Lesson Observation 2 transcript

Appendix C13: Mr. Zulu Lesson Observation 3 transcript

Appendix C14: Full Validated Lesson Observation Transcript

Appendix D: Field notes

Appendix D1: Mrs. Durand's field notes Lesson Observation 1


2014 JULY

THURSDAY 24

Date – 11 February 2022

Teacher Mrs Durand

Lesson — 1

FRIDAY 25

Topic Meiosis

Learners – Two classes combined – 60 male & Female learners

SATURDAY 26

Context

– In the Lab

Posters on the walls

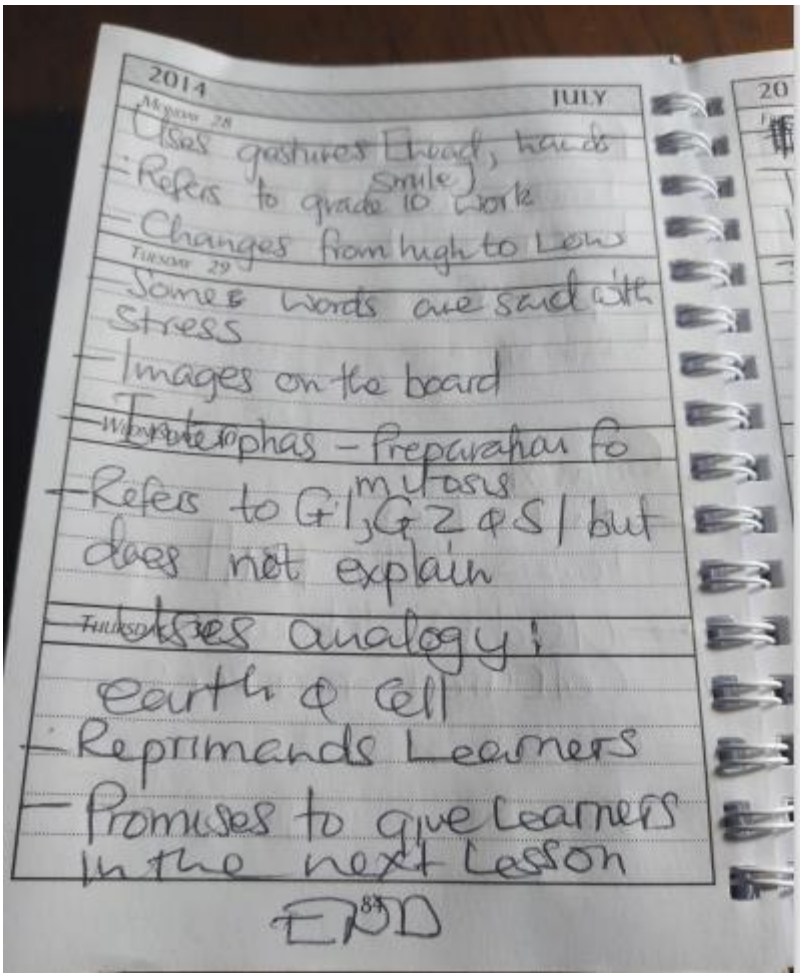
– Used Whiteboard & Coloured markers

SUNDAY

– Teacher refers to exams

– Uses the acronym IPMAT

83


2014 JULY
MONDAY 28
(Uses gestures (head, hands
smile)
- Refers to grade 10 work
- Changes from high to Low
TUESDAY 29
Some words are said with
Stress
- Images on the board
- Interphase - Preparation for
mitosis
- Refers to G1, G2 & S / but
does not explain
THURSDAY Uses analogy:
earth & cell
- Reprimands Learners
- Promises to give Learners
in the next Lesson
END

<u>Appendix D2: Mrs. Durand Lesson Observation 2 field notes</u>

<u>Appendix D3: Mrs. Letsiba Lesson Observation 1 field notes</u>

<u>Appendix D4: Mrs. Letsiba Lesson Observation 2 field notes</u>

<u>Appendix D5: Mr. Zindi Lesson Observation 1 field notes</u>

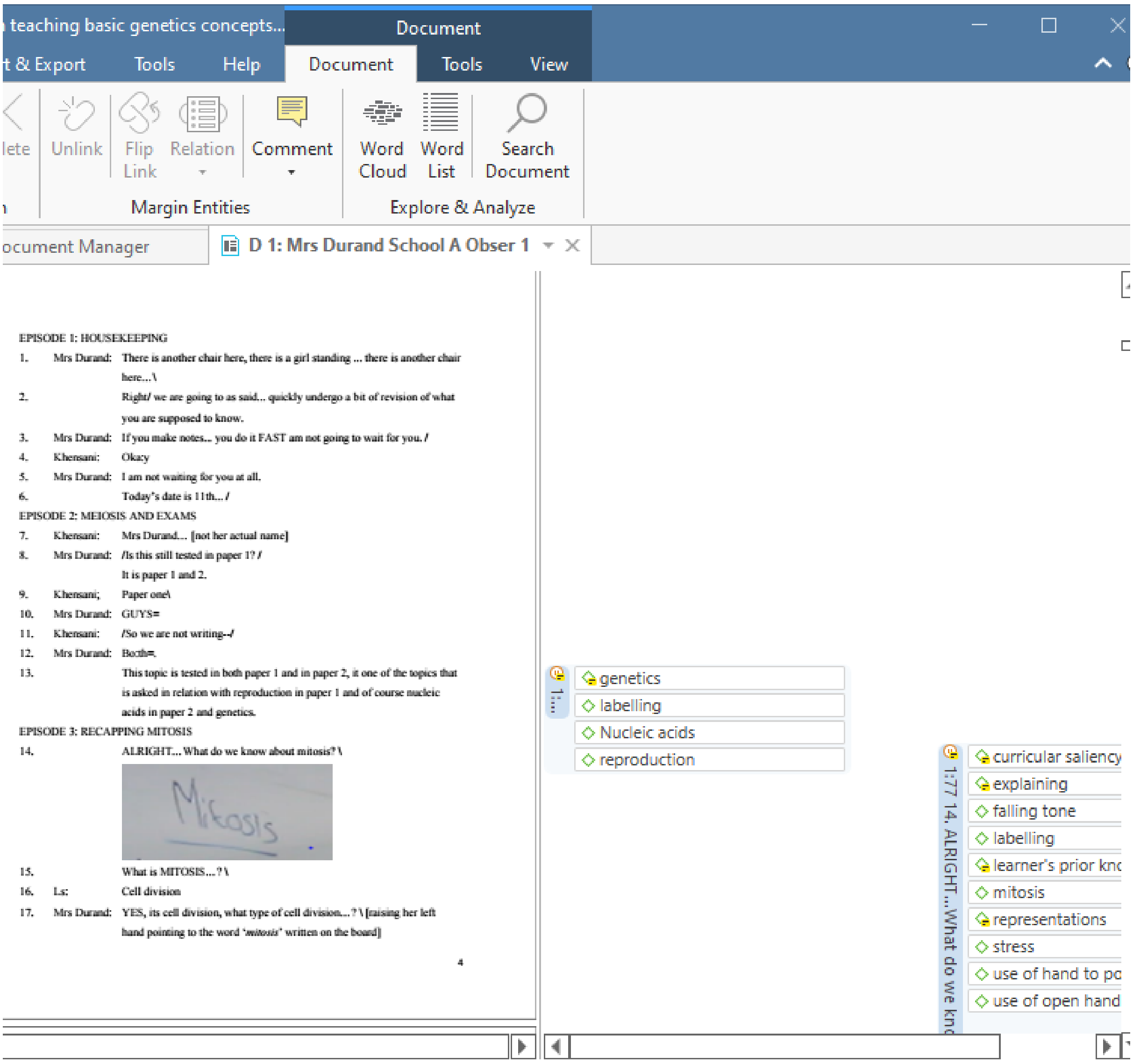
<u>Appendix D6: Mr. Zindi Lesson Observation 2 field notes</u>

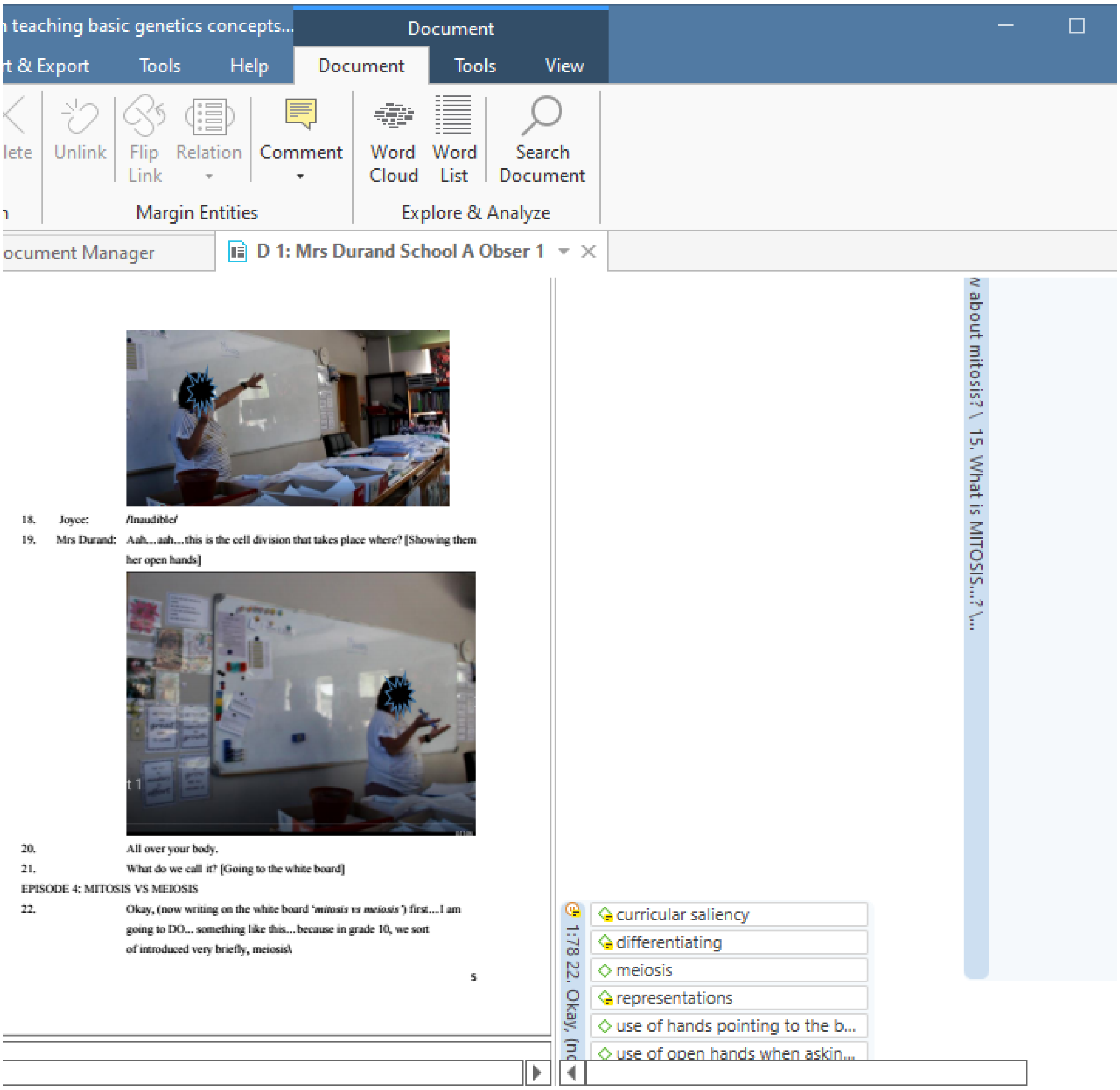
<u>Appendix D7: Mr. Zindi Lesson Observation 3 field notes</u>

<u>Appendix D8: Mr. Zulu Lesson Observation 1 field notes</u>

<u>Appendix D9: Mr. Zulu Lesson Observation 2 field notes</u>

Appendix D10: ATLAS.ti Coding part of Mrs. Durand Lesson Observation 1





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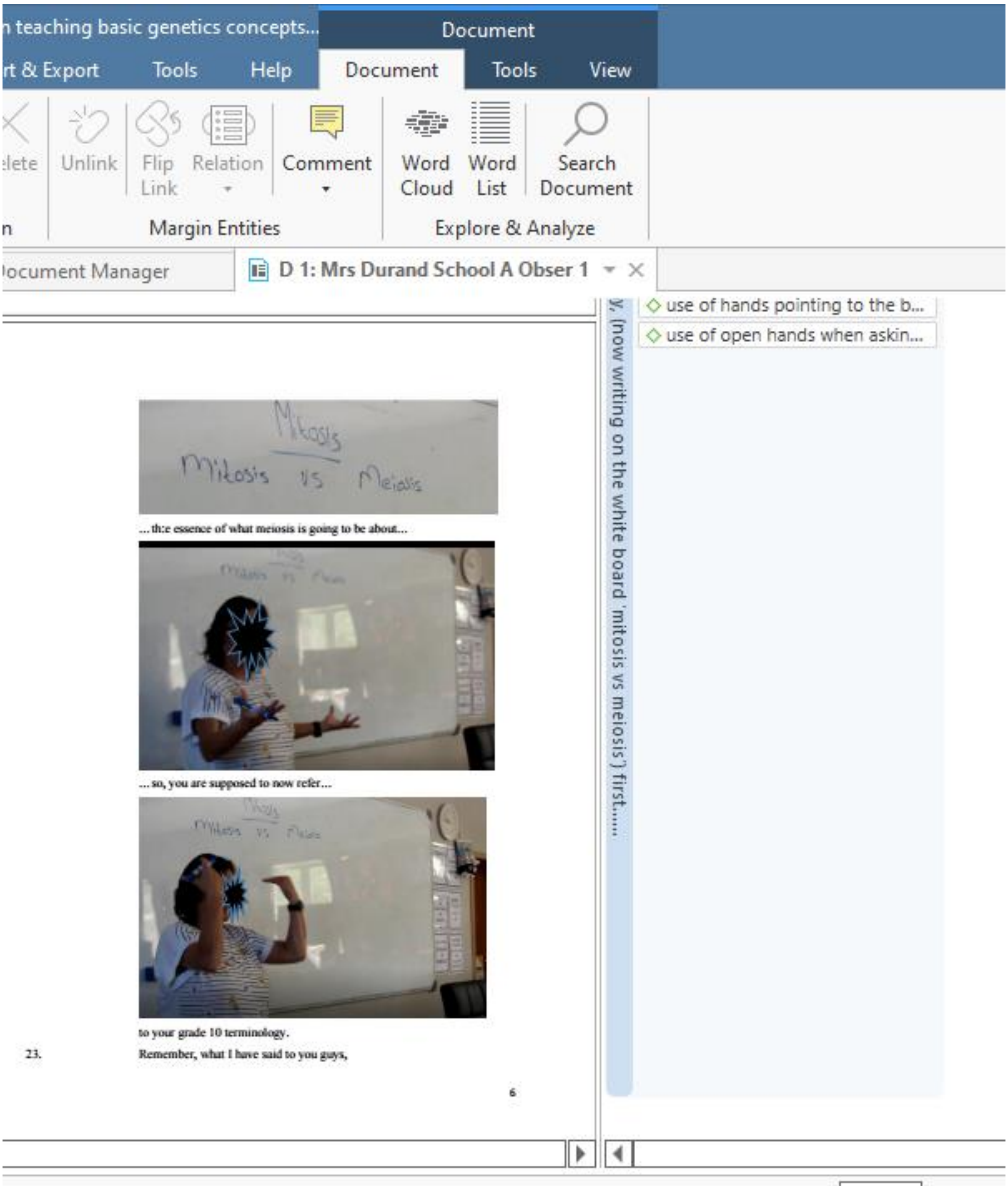
D 1: Mrs Durand School A Obser 1
18. Joyce: /Inaudible/
19. Mrs Durand: Aah…aah…this is the cell division that takes place where? [Showing them her open hands]
20. All over your body.
21. What do we call it? [Going to the white board]
EPISODE 4: MITOSIS VS MEIOSIS
22. Okay, (now writing on the white board 'mitosis vs meiosis') first…I am going to DO... something like this...because in grade 10, we sort of introduced very briefly, meiosis\
5
w about mitosis?\ 15. What is MITOSIS...?\...
1:78 22. Okay, (nc
curricular saliency
differentiating
meiosis
representations
use of hands pointing to the b...
use of open hands when askin...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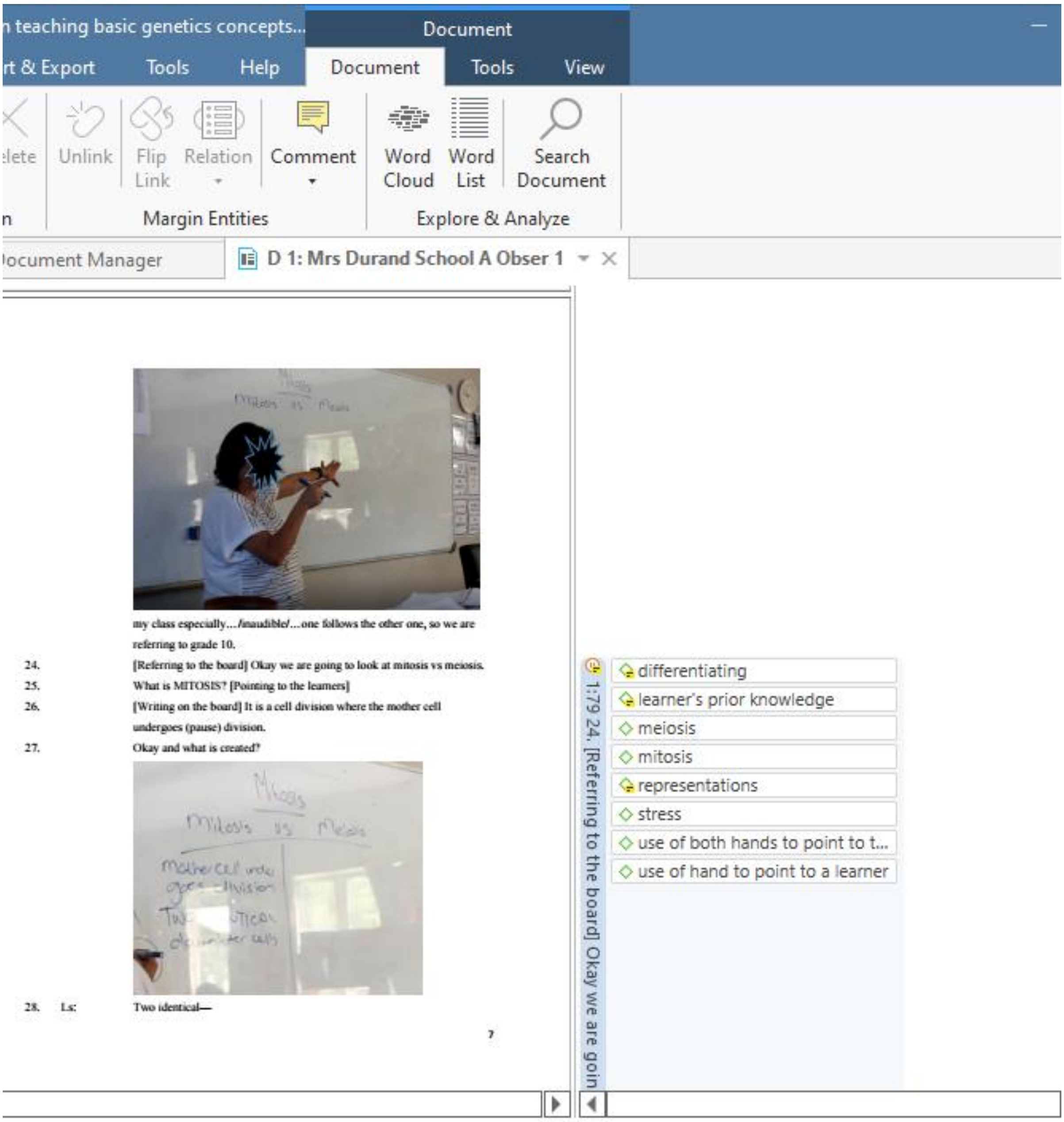
D 1: Mrs Durand School A Obser 1
use of hands pointing to the b...
use of open hands when askin...
y. (now writing on the white board 'mitosis vs meiosis') first.....
Mitosis
Mitosis vs Meiosis
...the essence of what meiosis is going to be about...
... so, you are supposed to now refer...
to your grade 10 terminology.
23.
Remember, what I have said to you guys,
6



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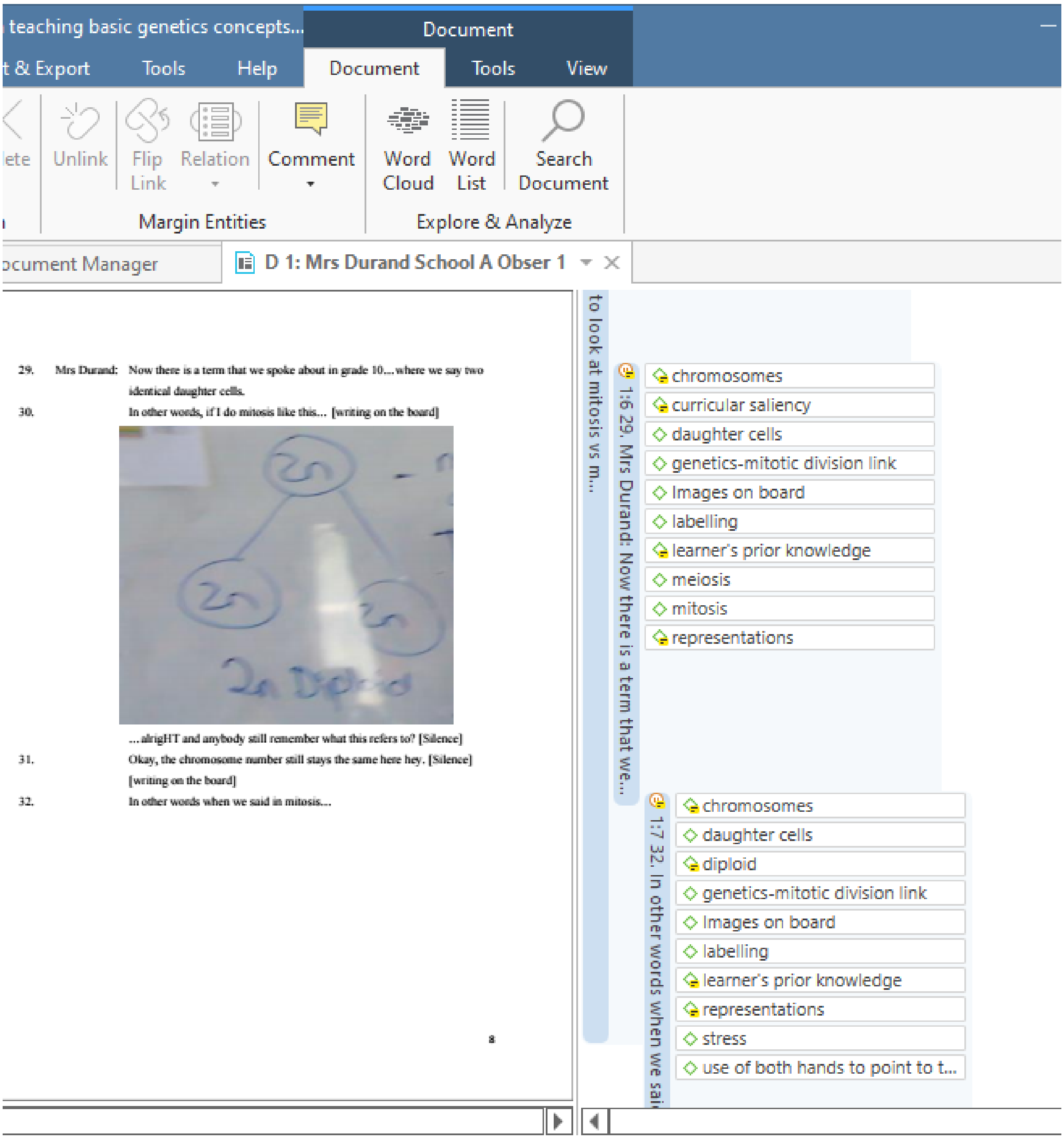
D 1: Mrs Durand School A Obser 1
my class especially.../inaudible/...one follows the other one, so we are referring to grade 10.
24. [Referring to the board] Okay we are going to look at mitosis vs meiosis.
25. What is MITOSIS? [Pointing to the learners]
26. [Writing on the board] It is a cell division where the mother cell undergoes (pause) division.
27. Okay and what is created?
28. Ls: Two identical—
7
1:79 24. [Referring to the board] Okay we are goin
differentiating
learner's prior knowledge
meiosis
mitosis
representations
stress
use of both hands to point to t...
use of hand to point to a learner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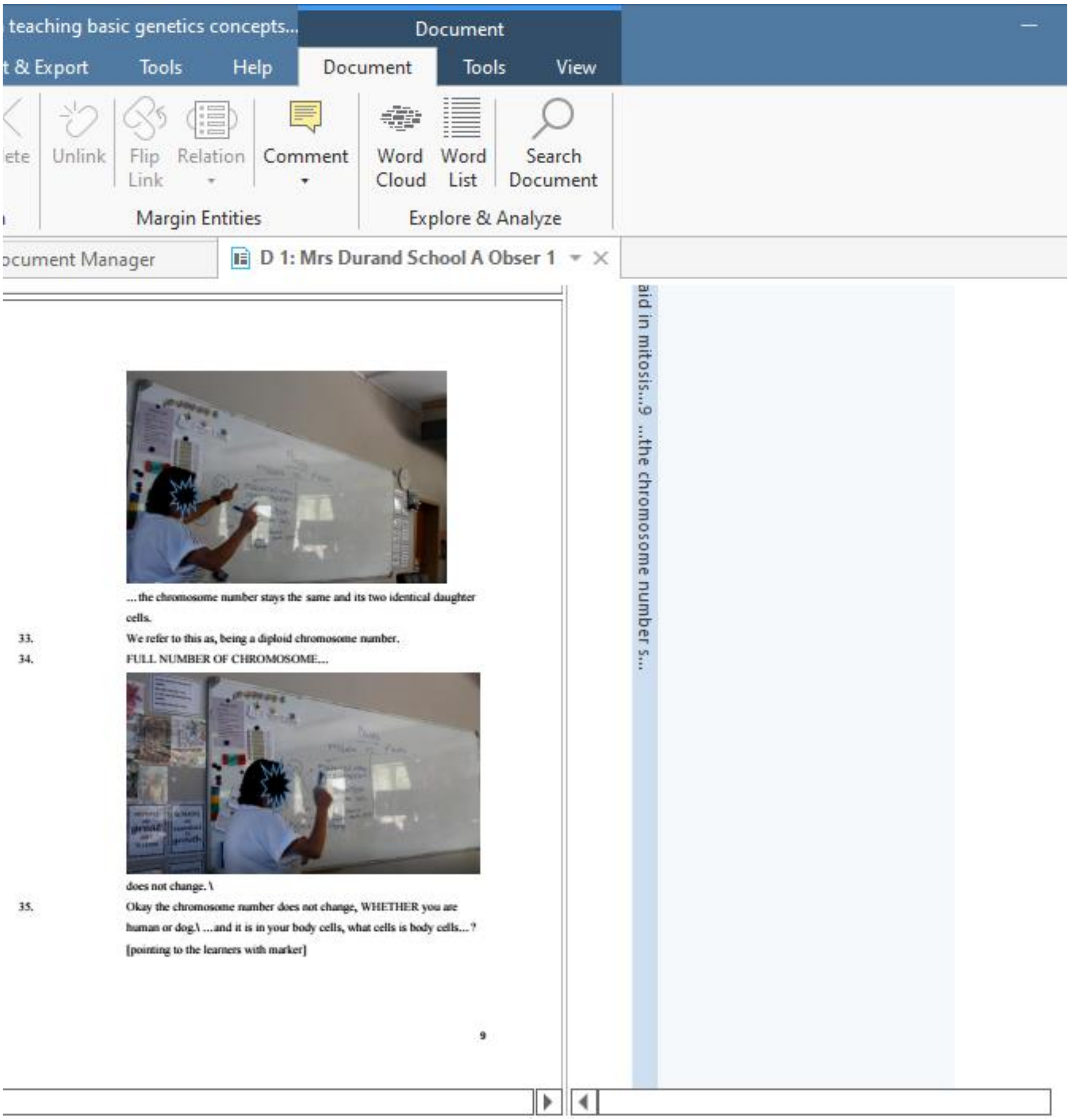
D 1: Mrs Durand School A Obser 1
29. Mrs Durand: Now there is a term that we spoke about in grade 10… where we say two identical daughter cells.
30. In other words, if I do mitosis like this… [writing on the board]
…alrigHT and anybody still remember what this refers to? [Silence]
31. Okay, the chromosome number still stays the same here hey. [Silence] [writing on the board]
32. In other words when we said in mitosis…
8
to look at mitosis vs m…
1:6 29. Mrs Durand: Now there is a term that we…
chromosomes
curricular saliency
daughter cells
genetics-mitotic division link
Images on board
labelling
learner's prior knowledge
meiosis
mitosis
representations
1:7 32. In other words when we sai
chromosomes
daughter cells
diploid
genetics-mitotic division link
Images on board
labelling
learner's prior knowledge
representations
stress
use of both hands to point to t…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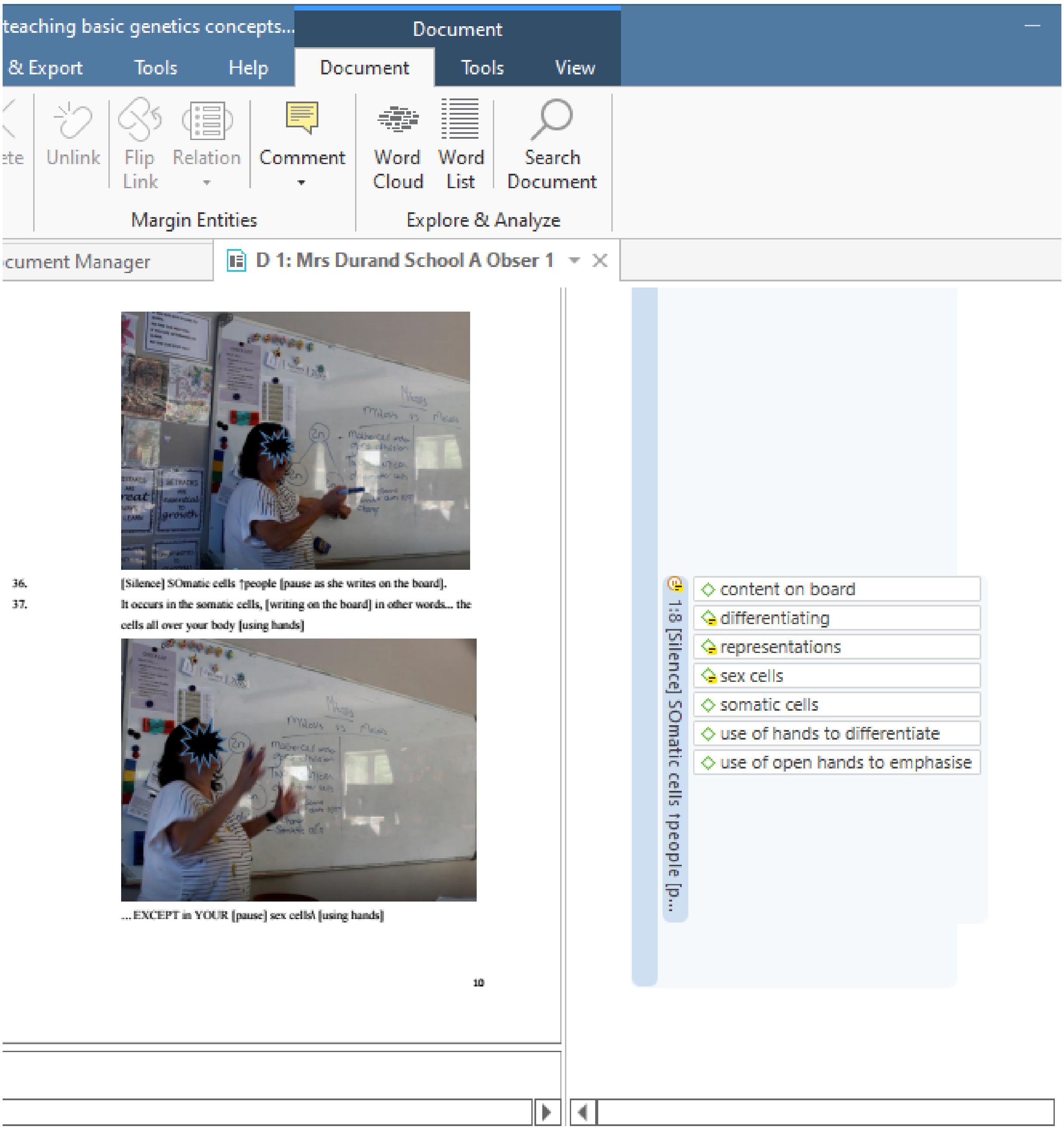
D 1: Mrs Durand School A Obser 1
...the chromosome number stays the same and its two identical daughter cells.
33. We refer to this as, being a diploid chromosome number.
34. FULL NUMBER OF CHROMOSOME...
does not change. \
35. Okay the chromosome number does not change, WHETHER you are human or dog.\ ...and it is in your body cells, what cells is body cells...? [pointing to the learners with marker]
9
aid in mitosis...9 ...the chromosome number s...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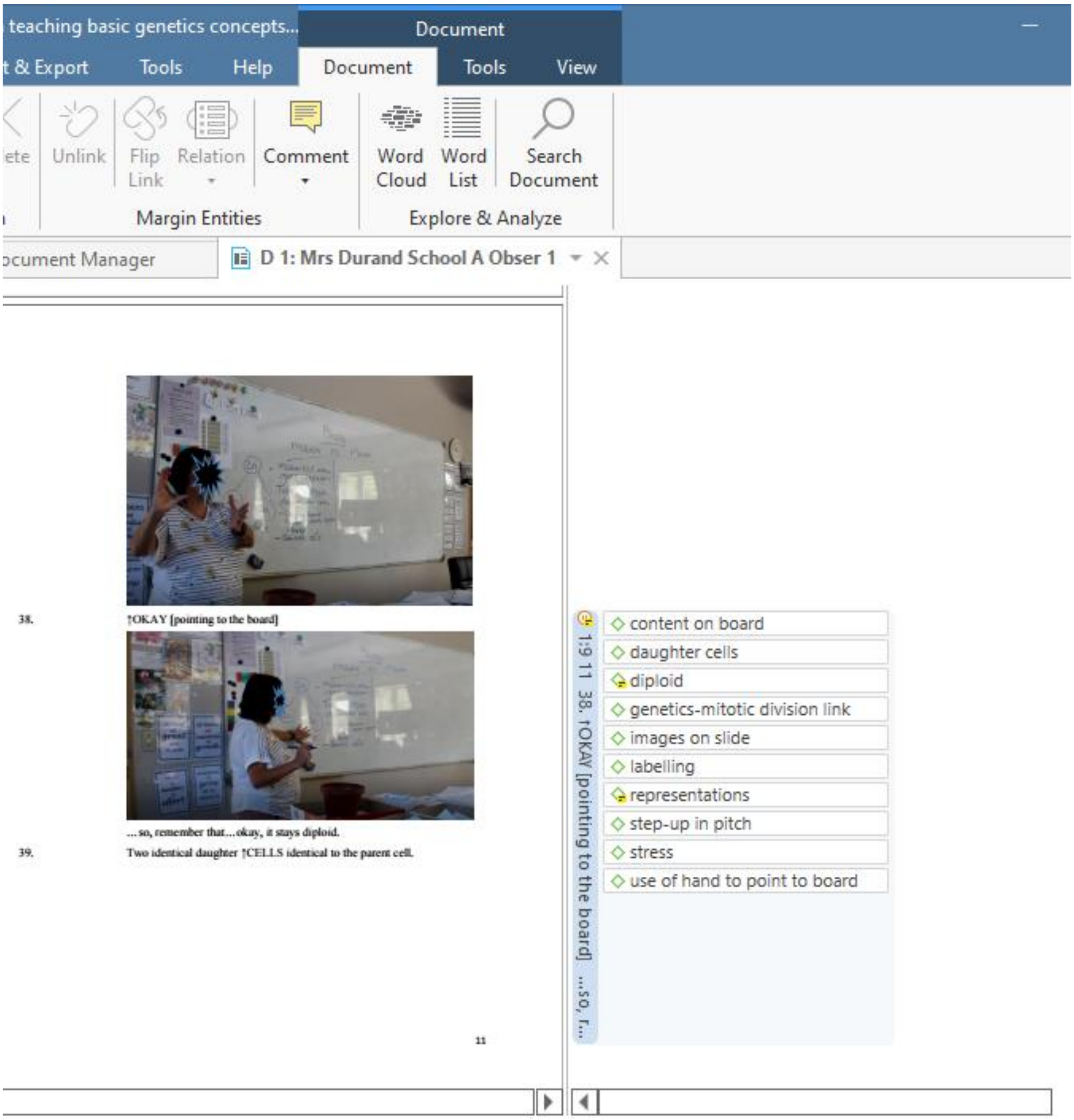
D 1: Mrs Durand School A Obser 1
36. [Silence] SOmatic cells ↑people [pause as she writes on the board].
37. It occurs in the somatic cells, [writing on the board] in other words... the cells all over your body [using hands]
...EXCEPT in YOUR [pause] sex cells\ [using hands]
10
1:8 [Silence] SOmatic cells ↑people [p...
content on board
differentiating
representations
sex cells
somatic cells
use of hands to differentiate
use of open hands to emphasise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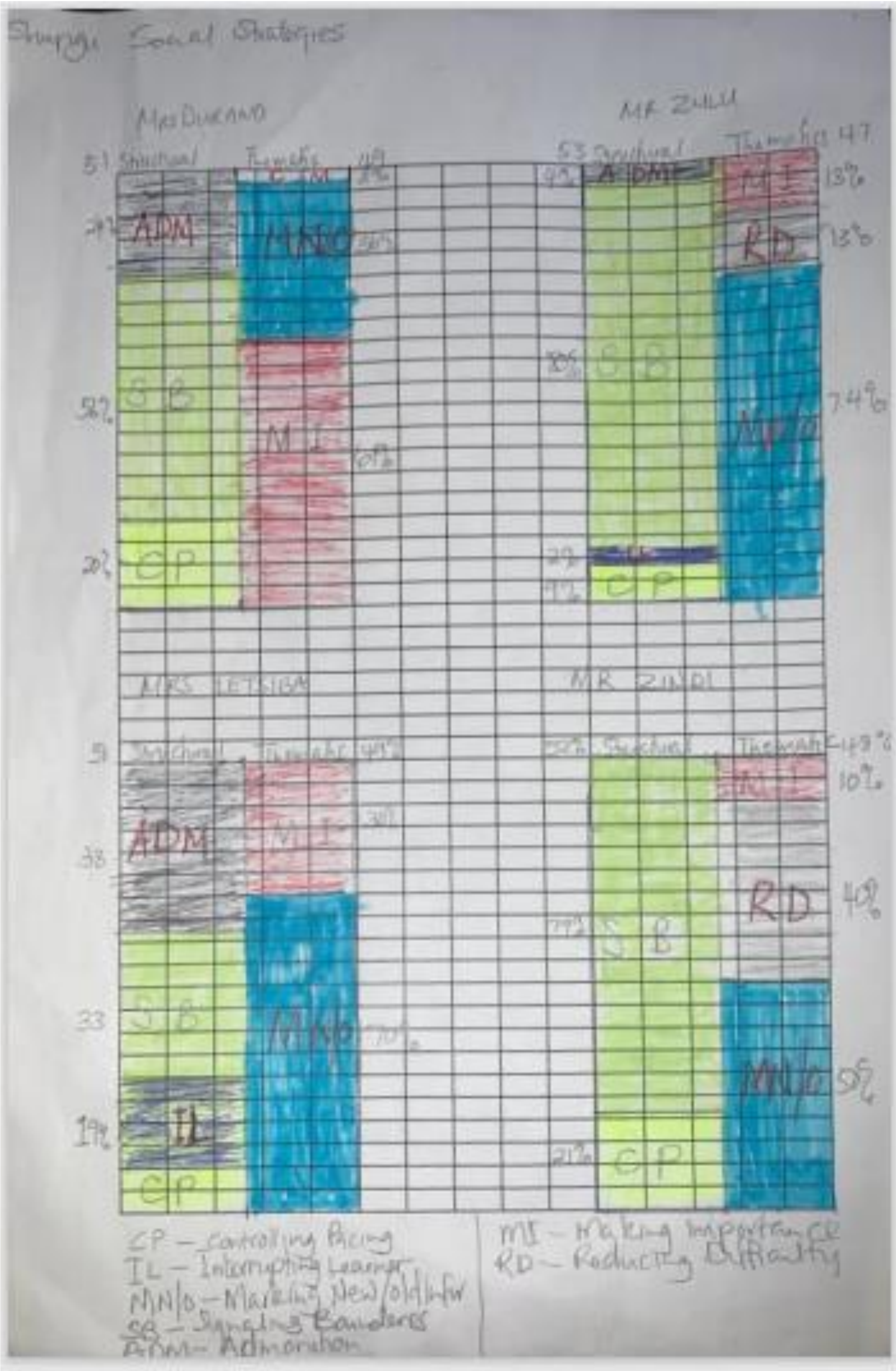
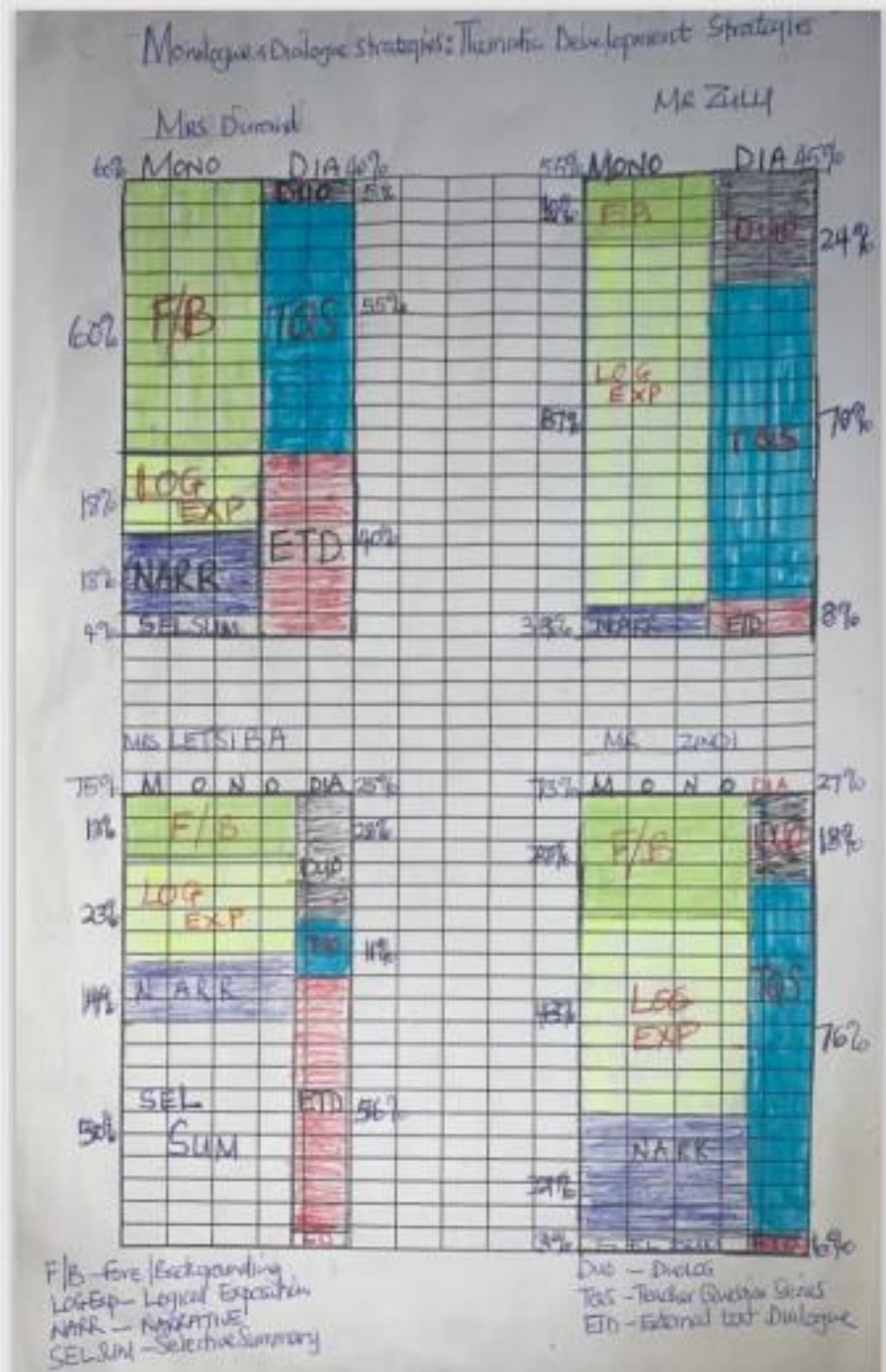
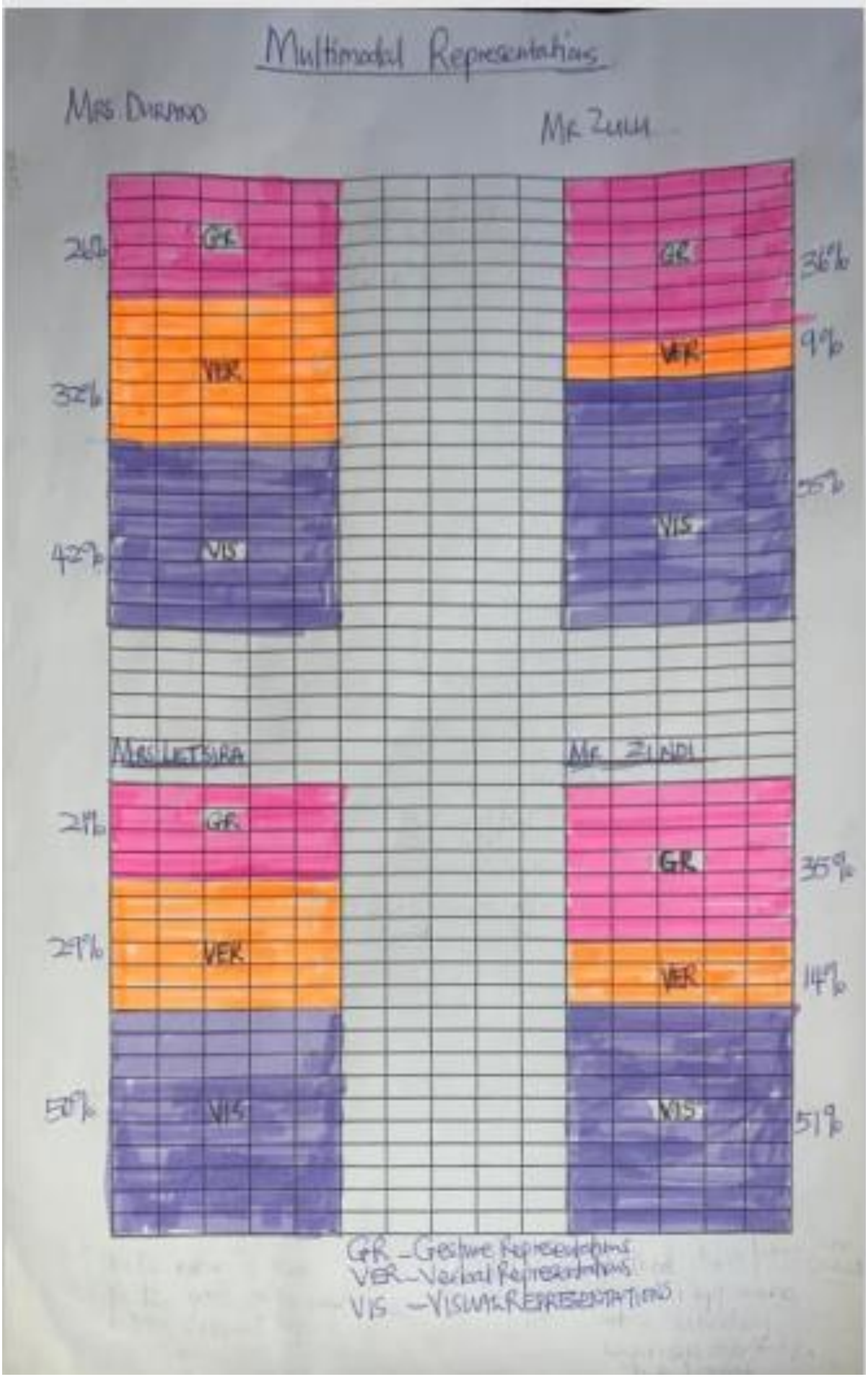
D 1: Mrs Durand School A Obser 1
38. ↑OKAY [pointing to the board]
... so, remember that...okay, it stays diploid.
39. Two identical daughter ↑CELLS identical to the parent cell.
11
1:9 11 38. ↑OKAY [pointing to the board] ...so, r...
content on board
daughter cells
diploid
genetics-mitotic division link
images on slide
labelling
representations
step-up in pitch
stress
use of hand to point to board

Appendix E: Teacher Discourse strategy 'Maps'




Monologue & Dialogue strategies: Thematic Development Strategies
Mrs Durand
Mr Zulu
60% MONO
DIA 40%
55% MONO
DIA 45%
DUO
5%
F/B
60%
TQS
55%
LOG EXP
18%
ETD
40%
NARR
15%
4%
SEL SUM
F/B
10%
DUO
24%
LOG EXP
85%
TQS
70%
NARR
ETD
8%
MRS LETSIBA
MR ZONDI
75% M O N O DIA 25%
73% M O N O DIA 27%
13%
F/B
28%
DUO
LOG EXP
23%
TQS
11%
NARR
14%
SEL SUM
50%
ETD
56%
F/B
20%
DUO
18%
LOG EXP
48%
TQS
76%
NARR
29%
3%
SEL SUM
6%
F/B – Fore/Backgrounding
LOGExp – Logical Exposition
NARR – NARRATIVE
SELSUM – Selective Summary
DUO – DUOLOG
TQS – Teacher Question Series
ETD – External text Dialogue


Multimodal Representations
MRS DURAND
MR ZULU
26%
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MRS LETSIBA
MR ZINDI
21%
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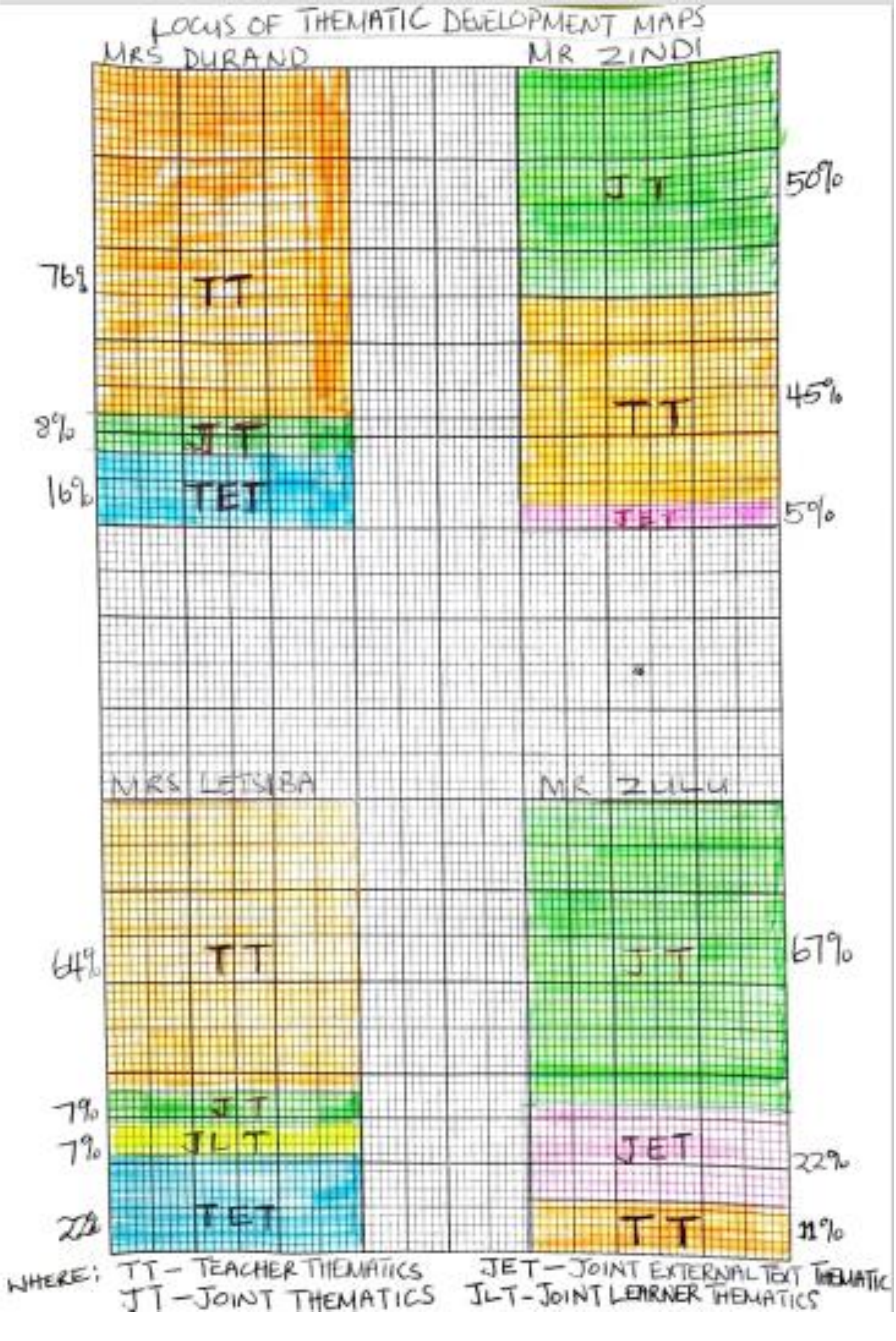
VIS
GR - Gesture Representations
VER - Verbal Representations
VIS - VISUAL REPRESENTATIONS


LOCUS OF THEMATIC DEVELOPMENT MAPS
MRS DURAND
MR ZINDI
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50%
TT
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5%
MRS LETSEBA
MR ZULU
TT
64%
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7%
JLT
7%
TET
22
JT
67%
JET
22%
TT
11%
WHERE; TT – TEACHER THEMATICS
JET – JOINT EXTERNAL TEXT THEMATIC
JT – JOINT THEMATICS
JLT – JOINT LEARNER THEMATICS

Appendix F: Pure Genetics Thematic Items used in this Study

Appendix F1: Mrs. Durand's Genetics Items

Father of genetics

Natural science

Genetics

Pea plants

Variety

Cross

Stamens

Artificially pollinate

Offspring

Genetics

Scientist

Homologous chromosomes

DNA

Doppler effect

Characteristic

Trait

Hybrid,

Self-pollination

Flower

Carpel

Pollen

Seeds

True breeding

Pure breeding

Appendix F2: Mrs. Letsiba's Genetics Items

Complete dominance

DNA

Alleles

Dominant

Recessive

Characteristic

Phenotype

Genotype

Gene

Offspring

Monohybrid cross

Homozygous

Chromosomes

Meiosis

Mitosis

Variation

Homologous chromosomes

Hereditary

Fertilization

Gametes

Father of genetics

Codominance

Genetic cross

Hybrid

First filial generation

Second filial generation

Appendix F3: Mr. Zulu's Genetics Items

Father of genetics

Cross

Pure breed

Offspring

F_1

P_1

P_2

P_1 plants

Tall plant

Short plant

Genetic makeup

Dominant

Alleles

Homozygous

Heterozygous

Gametes

Meiosis

Heterozygous alleles

Homozygous alleles

Phenotype

Dominant

Recessive

Genotype

Appendix F4: Mr. Zindi's Genetics Items

Father of genetics

Genetics

Experiments

True breeding

Pure breeding

Stamens

Pollen grains

Stigma

Variation

Varieties

Flower

Self-pollinate

Male organs

Reproduce

Fertilization

Offspring

F_1

F_2 hybrids

F1 generation

F_2 generation

Characteristic

Trait

Inherited

Species

Tall pea plant

Short pea plant

Smooth seeds

Wrinkled seeds,

Yellow pea seeds

Green pea seeds

Plant reproduction

Fruit

White flowers

Purple flowers

Hybrids

Hybridize

Animals

Organisms

Inheritable characteristics

Appendix G: Summary of Discourse Strategies

Appendix G

Appendix H: Common Sources for All Teaching

1. National Senior Certificate Life Sciences Curriculum and Assessment Policy Statement CAPS document https://www.education.gov.za
2. Life Sciences Examination Guidelines https://www.education.gov.za
3. Annual Teaching Plan (ATP) https://www.education.gov.za
4. Exam Fever Life Sciences Grade 12 Study Guide https://www.education.gov.za
5. Study Master Life Sciences Grade 12
6. Mind the Gap Study Guide
7. Chalk/White Board
8. Computer
9. Data Projector
10. PowerPoint
11. Learners' workbooks

END