

**Life Sciences teachers' use of talk moves to provide
opportunities for meaning-making**

by

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Acknowledgements and Dedication

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Abstract

Research has established the significance of learners making meaning of science concepts, especially during classroom interactions. These interactions are driven in part by teacher talk moves as pedagogical tools. However, talk moves and their usefulness in meaning-making have not been established in the South African context for the topic of population ecology in Life Sciences. Drawing from the socio-cultural theory as the main theoretical framework, the purpose of this study was to investigate how Grade 11 Life Sciences teachers use talk moves to provide learners with meaning-making opportunities when teaching the topic of population ecology, and the factors that influence this process. A conceptual framework with various constructs characterising teacher talk moves and teacher cognition was established to underpin the study.

Using a qualitative multiple case-study design, three teachers were sampled as participants. Audio recordings of lessons and Stimulated Recall Interviews were used as data sources. The teaching transcripts were analysed using Analysing Talk Moves, Teacher Discursive Moves, and Analysing Student Talk frameworks. The Stimulated Recall Interviews were analysed using both narrative analysis and analysis of narratives.

Findings show that teachers use a variety of talk moves to initiate interactions and specific rejoinders, such as challenging and clarifying moves, to provide learners with meaning-making opportunities. However, there were several instances where meaning-making opportunities were missed. Factors that influenced the teachers' use of talk moves include their cognition, time, and school context. These findings are discussed in light of the existing literature. This study offers insight into how population ecology can be made accessible for learners and highlights the need for professional teacher training in the use of talk moves.

Keywords:

Teacher talk moves, initiation moves, rejoinder moves, meaning-making, population ecology

Table of Contents

Clearance Certificate	i
Certificate of Language Editing.....	ii
Declaration	iii
Acknowledgements and Dedication	iv
Abstract	v
List of abbreviations.....	ix
List of figures	x
List of Tables	xi
CHAPTER 1: GENERAL ORIENTATION	1
1.1 Introduction	1
1.2 Background	1
1.3 Problem statement.....	5
1.4 Why the topic of population ecology?	5
1.5 Rationale	7
1.6 Purpose of the study and research questions	9
1.7 Summary of research methodology	9
1.8 Structure of the dissertation.....	10
1.9 Chapter Summary	11
CHAPTER 2: LITERATURE REVIEW AND THEORETICAL UNDERPINNINGS ..	12
2.1 Introduction	12
2.2 Conceptualising meaning-making.....	12
2.2.1 Meaning-making as defined in literature	13
2.2.2 Meaning-making compared to rote learning.....	16
2.3 Strategies for achieving meaning-making	19
2.4 Indicators of meaning-making during interactions	21
2.5 Science classroom talk and discourse	24
2.5.1 Classroom talk.....	25
2.5.2 Discourse in science classrooms.....	26
2.6 Talk moves in the science classroom	31
2.6.1 General literature on teacher talk moves	32
2.6.2 Initiation moves	35
2.6.3 Rejoinders	37
2.7 The teaching and learning of population ecology	40
2.7.1 Population ecology as a topic in the South African Life Sciences curriculum	40

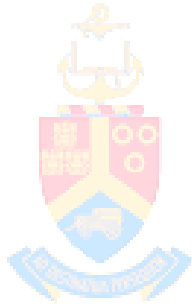
2.7.2 Taught misconceptions in the topic of population ecology	43
2.7.3 Teaching strategies used in population ecology	44
2.8 Teacher experiences with classroom talk	46
2.9 Conceptual framework	48
2.9.1 Socio-cultural perspective.....	49
2.9.2 Teacher cognition.....	51
CHAPTER 3: RESEARCH METHODOLOGY	55
3.1 Introduction	55
3.2 Research paradigm.....	55
3.3 Methodological approach.....	57
3.4 Research design	58
3.5 Research process	59
3.5.1 Selection of participants.....	59
3.5.2 Data collection procedures	62
3.5.3 Data analysis.....	65
3.6. Research rigour.....	68
3.7 Ethical considerations.....	69
3.8 Chapter Summary	70
CHAPTER 4: DATA ANALYSIS AND FINDINGS	71
4.1 Introduction	71
4.2 Detailed description of the analysis of audio-transcripts of lessons	71
4.3 Detailed analysis of the stimulated recall interviews	75
4.4 Presentation of findings	77
4.4.1 Case 1: Mandy	77
4.4.2 Case 2: Ntando	92
4.4.3 Case 3: Tebogo	107
4.5 Summary of findings	115
4.6 Chapter Summary	116
CHAPTER 5: DISCUSSION AND CONCLUSION	118
5.1 Introduction	118
5.2 Discussion of findings.....	118
5.2.1 Talk moves that Life Sciences teachers use when teaching population ecology	119
5.2.2 How the talk moves that teachers use in the classroom facilitate meaning-making of population ecology.....	125
5.2.3 Factors that contribute to the teachers' use of talk moves in the classroom to facilitate (or inhibit) meaning-making	129

5.2.4 Addressing the main research question	133
5.3 Significance of this study.....	135
5.4 Limitations of the present study.....	137
5.5 Implications of the study	139
5.5.1 Implications for pre-service teacher development.....	139
5.5.2 Implications for in-service teacher training	140
5.6 Future studies	141
5.7 Reflections on inquiry	143
5.8 Final remarks.....	145
6. REFERENCES	147
APPENDICES	159
Appendix A: University ethics approval letter.....	159
Appendix B: Gauteng Department of Education approval letter	160
Appendix C: Consent letter to principals	162
Appendix D: Consent letter to teachers.....	166
Appendix E: Consent letter to learners.....	170
Appendix F: Consent letter to parents	174
Appendix G: Field notes.....	178



List of abbreviations

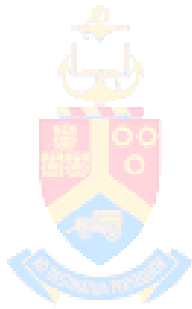
ATM:	Analysing Talk Moves
ATP:	Annual Teaching Plan
CAPS:	Curriculum and Assessment Policy Statement
DBE:	Department of Basic Education
IRE/F:	Initiation, Response, Evaluation/Feedback
PGCE:	Postgraduate Certificate in Education
SRI:	Stimulated Recall Interview
TDM:	Teacher Discursive Moves
ZPD:	Zone of Proximal Development



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List of figures

Figure 2.1 Dialogic and authoritative sequences	27
Figure 2.2 Conceptual framework for the study	48
Figure 4.1 Infographic on symbiosis	109



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List of Tables

Table 3.1 Teacher Profiles	60
Table 3.2 Lessons given and their duration	63
Table 3.3 Examples of questions asked during interviews	64
Table 3.4 Description of talk moves by the ATM and TDM frameworks	66
Table 3.5 Analysing Student Talk framework	67
Table 4.1 Lessons and number of episodes	72
Table 4.2 Example of coding lesson transcripts	74
Table 4.3 An example of coding the interview transcripts	75
Table 4.4 Prevalence of talk moves in Mandy's lessons	78
Table 4.5 Prevalence of talk moves in Ntando's lessons	92
Table 4.6 Prevalence of talk moves in Tebogo's lessons	107



CHAPTER 1: GENERAL ORIENTATION

1.1 Introduction

In this chapter, I begin by unpacking the concepts of meaning-making and teacher talk within the broader perspectives of science classroom talk and interactions, to provide the background of the study. I then detail the problem statement and rationale that led to this study. This is followed by my discussion of the purpose of the study and the research questions that guided this study. I summarise the research methodology, which will be discussed in more detail in Chapter 3. I close the chapter by outlining the structure of the dissertation.

1.2 Background

Research in science education has shown that classroom interactions allow students to make meaning of science concepts (Jaipal, 2010; Kelly, 2013; Scott, 2004; Wilmes & Siry, 2021). There is agreement amongst scholars in science education that when learners make meaning of science concepts, they are likely to attain conceptual understanding (Fägerstam & Blom, 2013). Conceptual understanding is defined as “the ability to see interconnections between concepts” (Puk & Stibbards, 2011, p. 2). For learners to attain conceptual understanding, they need to make meaning of the science concepts. The process of meaning-making is dependent on the opportunities provided by the teacher.

Ajayi (2008) defined meaning-making from the perspective of the learners by arguing that it is attained when learners draw from their experiences and by linking these experiences with science knowledge. Central to Ajayi’s (2008) definition is that learners use their worldview to internalise science concepts. This

definition suggests that science teachers need to engage learners in meaningful activities where learners can relate what is being taught to their experiences and prior knowledge (Ausubel, 1963) to enhance the process of meaning-making (Mills, 2016).

One of the ways reported in the literature to provide learners with meaning-making opportunities is through engaging them in whole-class discussions where they can voice their ideas (Rudsberg et al., 2017). Literature on interactions in science classrooms argues that when learners are engaged in discussions, they can relate what they have experienced in their everyday lives to what they are currently learning (Agra et al., 2019; Kasworm, 2003). This relation of ideas is because, through interactions, learners can make links between concepts as argued by Fägerstam and Blom (2013) and Scott et al. (2011).

However, the teacher is the one responsible for driving the interactions that can result in meaningful learning. In essence, through the use of talk moves, teachers can provide learners with opportunities to make meaning of science concepts. Michaels and O'Connor (2015) define talk moves as pedagogical tools that help teachers respond to challenges during a discussion when delivering content. These talk moves are further described as utterances that the teacher uses to boost learners' morale and motivation to engage with the content (Sakka et al., 2022).

Talk moves encourage interaction by driving learners' engagement with the content being taught to understand concepts by bringing to light misconceptions learners have about the natural world (Bansal, 2018), and addressing those

misconceptions by giving feedback to learners. Talk moves not only encourage learners to engage with the content but also encourage learners to build their own understanding and critically examine ideas, under the teacher's guidance, to make meaning (Haber, 2020; Jonassen et al., 1998) out of topics that pose a challenge. Without talk, learning can come to a halt (Wei et al., 2018). Some scholars call talk moves 'discursive moves' (Correnti et al. (2015); Tytler and Aranda (2015). In the remainder of this dissertation, this term (discursive moves) will also be used to refer to teacher talk moves that drive classroom interactions.

In science classrooms, interaction is initiated when the teacher asks learners a question or gives a prompt in the form of a diagram to invite learner contributions (Khoza & Msimanga, 2021; Soysal, 2022). The teacher would then evaluate or provide feedback to the learner's answer. This follows the Initiation-Response-Evaluation/Feedback (IRE/F) interaction pattern of Sinclair and Coulthard (1975). Due to its rigidity, the IRE/F model requires some modification to increase learner engagement (Waring, 2009). This is because the IRE/F interaction pattern focuses on the teacher, and only the teacher has the power to drive the conversation, if any, in the classroom (Clifton, 2006). This concentration of power on the side of the teacher disempowers the learners and hinders their engagement and thus their process of meaning-making (Brand, 2016). A more liberal framework is that of Correnti et al. (2015), which, in addition to the initiation moves, adds rejoinders as talk moves used by the teacher.

Rejoinder moves are described as teacher responses to the contribution of the learners beyond the evaluation and provision of feedback during classroom

discussion (Correnti et al., 2015). Rejoinder moves broaden the teacher's possible responses to go further than just evaluating or giving feedback to the learner as the teacher manipulates learners' contributions to create opportunities for meaningful learning (Buma & Nyamupangedengu, 2020). The rejoinder moves expand the classroom conversation (Park et al., 2017) by inviting learners to engage actively with the lesson (Mesa & Lande, 2014).

The implication of these arguments is that talk moves give learners more room to speak, which can help them develop a richer understanding of the concept being taught, thus promoting meaning-making. Therefore, the use of rejoinder moves instead of an evaluation is encouraged in science classrooms. Tytler and Aranda (2015) suggest a variety of rejoinder moves that can allow heightened learner interactions, such as asking an extended question and providing information for further learner contributions. As such, the use of such rejoinders may allow opportunities for meaning-making. However, this may be influenced by several factors that this study aims to reveal.

Grapin et al. (2019) and Soysal (2021) propose that the use of talk moves is subject-specific because each subject has its own language. This study, therefore, seeks to explore teacher-talk moves in how they afford learners the opportunity for meaning-making in the topic of population ecology in the Life Sciences classroom. Classroom talk and meaning-making are intrinsically linked (Rudsberg et al., 2017). Through their talk, the teacher can inspire learners' confidence and curiosity, which potentially leads to meaning-making as the learners share their ideas with their classmates (Sampson & Clark, 2009). Given the significance of teacher talk moves in facilitating interactions, thus providing

learners with opportunities for meaning-making in specific topics, this study sought to explore how teachers use discursive moves to provide opportunities for meaning-making when teaching the topic of population ecology. Because of its often abstract nature, the topic of population ecology requires specific teaching tools that the teacher uses to reach the learners. Such tools include talk moves tailored to make the topic relevant and accessible to learners.

1.3 Problem statement

Traditionally, the way of teaching Life Sciences is the transmission method, which does not encourage learner interaction (Tachie, 2020). A few studies have shown that this is the predominant method of teaching in South Africa (Fridman et al., 2003; Makhubele et al., 2019). This is one-directional teaching, with information only coming from the teacher to the learner and makes the learner a bystander in the classroom, especially since most learners tend to trust teachers without question (Teo, 2016). The transmission method of teaching prevents learners from constructing meaningful knowledge and understanding the content (Kranzfelder et al., 2020; Precious & Feyisetan, 2020) since they do not have the chance to voice their opinions or ask questions. Therefore, learners find some concepts of Life Sciences to be abstract and not real-life based, making it difficult to understand and retain them (Lazarowitz & Penso, 1992).

1.4 Why the topic of population ecology?

One of the most difficult topics to understand in Life Sciences is population ecology (Nevanpää & Law, 2006). Learners have misconceptions regarding different sections of the topic of population ecology (Munson, 1994). For example, learners confuse different terms such as species and population, and use them

interchangeably (Department of Basic Education, 2021c). One of the ways of dealing with these misconceptions and confusions is through encouraging more learner-centred teaching where learner engagement is valued (Skosana & Monyai, 2013). Encouraging learner-centred teaching is also emphasised by the South African science curriculum (Department of Basic Education, 2011a; Le Grange, 2019; Malcom & Samuel, 2019). Without a discourse where learners' voices are heard, learners will have difficulty in making sense of the concept of population ecology. It is, therefore, important for the teacher to establish a discourse where ideas are shared.

Despite the potential for learners to observe the dynamics of population ecology in their everyday lives, such as in the news, learners seem to struggle with the concepts in this topic. It has been found that learners have misconceptions regarding sections of this topic such as density-dependent regulation, carrying capacity, population cycles, predator-prey interactions, and environmental limiting factors (Munson, 1994). This confusion may arise because this topic is overshadowed by phrases such as 'Balance of Nature', 'Web of Life', and 'Mother Nature' (Hovardas & Korfiatis, 2011), which do not sound scientific, but are rather the oversimplification of population ecology concepts (Hovardas & Korfiatis, 2011), detracting from the importance of this topic and leaving the impression that understanding the concepts is unnecessary. The misconceptions are further exacerbated by misleading and oversimplified textbooks (Korfiatis et al., 2004). Hence, in this study, I looked at the talk moves that teachers use when teaching population ecology, and how these encourage learner meaning-making of population ecology concepts.

1.5 Rationale

The rationale of this study is two-fold, emanating from the literature and practice gap. In terms of the literature gap, studies have looked at meaning-making in science classrooms. However, these studies have focused on how learners make meaning of science concepts. For example, Larsson and Kakobsson (2019) investigated how hybrid language is used by learners in science classrooms to explain science concepts within everyday and scientific concepts. Other studies focused on meaning-making in practical work (e.g., Pun & Cheung, 2021).

Although some studies focused on teachers, these studies investigated questioning strategies, mostly in Physical Sciences classrooms (e.g., Khoza & Msimanga, 2022; Pedrosa-de-Jesus et al., 2016; Soysal, 2022). Furthermore, these studies did not seem to focus on specific topics. Given that science teaching in its overall sense is topic-specific, strategies (teacher talk and questioning in this case) that teachers employ need to be topic-specific (Mavhunga & Rollnick, 2013). This study aims to contribute to closing this gap in two ways. Firstly, this study investigates not only talk strategies for meaning-making but also overall interaction patterns that are characterised by how the teacher responds to learner contributions to facilitate meaning-making.

Secondly, this study focuses on a specific topic that is seemingly neglected in science education, as argued in the problem statement – population ecology. Therefore, this study can possibly contribute to the body of knowledge about population ecology education research to address the current deficiency in this field. In this study, this was done by highlighting how teachers utilise talk in their

lessons to involve learners in the classroom. It also contributes to the knowledge of how teachers can facilitate or prevent meaning-making of population ecology using talk.

In terms of practice, as noted above, the topic of population ecology is problematic in terms of teaching (Cooke et al., 2021) and learning (Acevedo, 2020). Investigating this topic would not only serve the purpose of investigating discursive moves that teachers can use to provide opportunities for meaning-making but also as an indication of how different learner contributions can be followed up to explore those opportunities. Insight into teachers' talk moves to facilitate meaning-making opportunities for learners while teaching the topic of population ecology may extend the current understanding of the role of teacher talk moves in South African science classrooms.

The study can potentially lead to more research into teacher talk moves and renewed interest and further research on the neglected field of the teaching and learning of population ecology. The study can also contribute to teacher development regarding teacher training in talk moves and their usage in the Life Sciences classroom. This training can highlight how the 'chalk-and-talk' method is detrimental to the learners' meaning-making (Nwaeze et al., 2016) of not just population ecology, but other topics in Life Sciences as well.

Being a novice Life Sciences teacher who values learner engagement and having limited experience in teaching the subject, I became interested in learning how other teachers deliver Life Sciences content by engaging the learners in classroom talk, and how this unfolded in different contexts. This interest included

how the teachers teach population ecology because of its apparent isolation from other topics in the Life Sciences curriculum.

1.6 Purpose of the study and research questions

Given the problem statement above, the purpose of the present study was to understand how teachers use discursive moves to provide learners with opportunities for meaning-making when teaching the topic of population ecology. Furthermore, I also looked at the factors that influence the use of these discursive moves. This study was guided by the main research question:

How do Life Sciences teachers use talk moves to afford learners with meaning-making opportunities when teaching population ecology?

The main research question was divided into three sub-questions:

1. What talk moves do Life Sciences teachers use when teaching population ecology?
2. How do the talk moves that teachers use in the classroom facilitate meaning-making (or not) of population ecology content?
3. What factors contribute to teachers' use of talk moves in the classroom to facilitate meaning-making?

1.7 Summary of research methodology

For this study, I used an interpretivist paradigm. This paradigm is fitting for the current study because it focuses on the social context of teachers (Pervin & Mokhtar, 2022). This paradigm led to a qualitative research approach (Cohen et al., 2017) being used in this study. My study was a multiple case study with each

teacher being a separate case, allowing me to collect data and analyse from each teacher individually due to their unique contexts. I chose a multiple case study because teachers have different realities (Mfinanga et al., 2019) that influence their teaching; thus, factors may differ. The participants were three Grade 11 Life Sciences teachers in Gauteng province. The data collection methods were audio recordings of the teachers' lessons (supported by field notes) as well as stimulated recall interviews (SRI). I transcribed and analysed the data from the lessons and interviews separately. For the audio data, I used the Analysing Talk Moves (ATM) framework by Correnti et al. (2015), which breaks down the different forms of talk moves that the teacher uses, comprising an initiation move, a response from the learner, and a rejoinder. This framework allowed me to see the instances where learners made meaning of the topic of population ecology. I supplemented the ATM framework with that of Tytler and Aranda (2015) to describe the moves in the ATM framework. For the learner talk moves, I used the Analysing Student Talk (AST) framework by Hardman (2019), which describes the learner talk moves in classroom talk. The SRIs were analysed using both the narrative analysis and analysis of narratives approaches.

1.8 Structure of the dissertation

The first chapter of this dissertation introduces the study. This chapter outlines the purpose, research questions and scope of the study. The second chapter is a review of the available local and international literature that is related to talk moves, meaning making as well as population ecology education and the theoretical perspectives underpinning the study. Chapter 3 explains the methodology and steps taken to undertake this study. It details the design,

instrumentation, data collection methods, sampling, as well as the data analysis procedure. Chapter 4 is a presentation of findings of the study and the analysis thereof. The fifth and final chapter is the discussion of the findings as presented in the fourth chapter. In Chapter 5, I also show how the findings address the research question and detail the significance and recommendations that emerged from this study.

1.9 Chapter Summary

This chapter was an introduction to the study. I presented the background to the study, problem statement, and rationale for the study, which detailed the research gap that will be filled by the present study. The chapter laid out the research questions that guided this study as well as the research design and methodology to answer the research questions. In the next chapter, I discuss the current literature landscape regarding meaning-making, talk moves, and population ecology, as well as the theoretical framework.

CHAPTER 2: LITERATURE REVIEW AND THEORETICAL UNDERPINNINGS

2.1 Introduction

This chapter focuses on the literature relevant to this study. This literature review covers multiple aspects of the themes in this study. In Section 2.2, I conceptualise meaning-making by defining it from literature, contrasting meaning-making with rote learning, and detailing the strategies used to achieve meaning-making. In Section 2.3, I focus on the strategies and indicators of meaning-making in Section 2.4. The next Section, 2.5, focuses on science classroom talk and discourse. Section 2.6 deals with talk moves in the science classroom, detailing talk moves in the classroom, which comprise initiation and rejoinder moves. Section 2.7 details literature regarding the teaching and learning of population ecology, consisting of population ecology in the science curriculum, the priority given to population ecology, the taught misconceptions of population ecology, and the teaching strategies that teachers use when teaching population ecology. In Section 2.8, I detail the experience of teachers concerning talk. Lastly, in Section 2.9, I present the conceptual framework (drawing from multiple concepts and constructs) that guided this study, as well as the theoretical underpinnings of the study: socio-cultural theory.

2.2 Conceptualising meaning-making

The section discusses how meaning-making is contextualised in the classroom. I discuss how meaning-making is defined by existing literature and discuss its comparison with rote learning, both of which exist on a spectrum.

2.2.1 Meaning-making as defined in literature

There is no clear definition of meaning-making in literature. Scholars have used different terms, such as meaningful learning and sense-making, to explain what meaning-making is. These terms are often used interchangeably. Ajayi (2008) defines meaning-making as a process by which learners gain a critical consciousness of the interpretation of events in their lives about the world around them. This definition underscores the significance of the learners' prior knowledge as well as the contexts they come from.

Vygotsky (1978) refers to meaning-making as a process of internalising new information through social interactions, and learners need to build that meaning for themselves (Gee, 2003). Vygotsky's definition is in terms of what happens when learners take in new information in their schema. Kinchin and Hay (2005) posit that meaning-making is the interaction of new knowledge with what is already in the learner's cognitive structure during the process of assimilation and accommodation of new information into their schema.

Champe et al. (2005) assert that meaning-making refers to "a process in which students link new information to relevant concepts that they already possess" (p.10). While this definition also underscored the role of learner prior knowledge, it was influenced by David Ausubel, who, in the context of educational psychology, posited that meaning-making is a learning process in which "the learner employs a meaningful learning set and that the material he learns is potentially meaningful to him" (Ausubel (1963, p. 22). From these definitions, there seems to be a common theme – the role of the learner's prior knowledge and the significance of engagement with the new content learnt. This has

implications for how teachers provide learners with opportunities to make meaning of science concepts. The starting point would be acknowledging that learners bring a wealth of knowledge to science classrooms.

Previously, the field of educational psychology proposed that learners are essentially empty vessels and are waiting for new information from outside of themselves (Grove & Bretz, 2012). The theory of meaning-making opposes this position because learners acquire knowledge from their everyday interactions outside the school premises. Ausubel (1963) argued that the biggest factor that impacts learning is the learner's prior knowledge. Ausubel's assertion is supported by that of Vygotsky (1978) that the learner is not merely a plain canvas to be filled but already has their life experience, which constitutes prior knowledge that new knowledge will fit into. By understanding what the learner already knows, the teacher can then tailor their lessons accordingly.

To learn meaningfully is to constantly question one's values and preconceptions considering new information. This is because the process aims to make learning worthwhile (Kostiainen et al., 2018). As such, meaning-making involves evaluating one's ideas, beliefs and assumptions to form meaning while taking into account what is already known to the individual (Fiddler & Marienau, 2008). In science classrooms, this prior knowledge may not be in line with the science perspectives of viewing the world. However, it is significant as a vehicle through which learners can be enculturated into the scientific way of explaining natural phenomena (ter Borg, 2022).

Meaning-making, therefore, requires the incorporation of new knowledge into the schema of prior knowledge. New knowledge anchors itself into previous information, eventually causing an expansion of the cognitive structure (Ausubel, 1963). This anchorage of new knowledge stabilises the prior knowledge and increases its capacity to become a foundation for more, newer knowledge (Agra et al., 2019). This stability arises when the learner has situated the new knowledge well into prior knowledge. The assimilation of new information into old information allows learners to evaluate what they already know, compare it with the new information, and combine the two accordingly or discard some aspects of the prior knowledge if necessary, which constitutes meaning-making (Agra et al., 2019). Thus, meaning-making is an ongoing process facilitated by the provision of tools. In this study, talk moves are taken as tools that can facilitate the process of meaning-making in science classrooms.

To ascertain whether new learning is meaningful, two criteria must be met. The first criterion is that the new information must have a functional sense of the relevant concepts in the cognitive structure (Ausubel, 1963; Seker, 2004). The relevance of this criterion is that if there are no concepts already in the cognitive structure, the new information cannot be assimilated into the prior knowledge. The second criterion is that the relevance must be to existing knowledge and must feature concepts and issues that are significant to the prior knowledge (Ferreira-Valente et al., 2021; Novak, 2002). The second criterion is important because the extent to which learning is meaningful depends on the significance that the learner assigns to the new learning based on their beliefs, feelings, and experiences (Agra et al., 2019; Fiddler & Marienau, 2008). The perception of

relevance of the new information by the learner plays a crucial role in meaning-making. In other words, if learners do not find the new content relevant, they may resist engaging with it.

However, meaning is not only characterised by personal significance and connections made by the learner between new and old knowledge but also by the formation of new beliefs, shifting from simply understanding to acting, as well as the development of new skills (Fiddler & Marienau, 2008; Novak, 2002). It is important that the learner consciously chooses to look for connections between knowledge; otherwise, the learning will not be meaningful. Instead, it will lead to rote memorisation (Grove & Bretz, 2012), which does not constitute meaning-making. Indeed, the properties of the cognitive structure determine how clear and valid the meanings that emerge are, as new information is added into the cognitive structure, and how it is assimilated (Ausubel, 2012). This integration of new knowledge with prior knowledge must be an active process, which in science classrooms can be facilitated through talk (Studhalter et al., 2021). The cognitive structure is a major factor influencing meaning-making, which is why it must include ideational content, the required experience, and the intellectual capacity required to process the new information to reap the benefits of meaning-making (Ausubel, 1963).

2.2.2 Meaning-making compared to rote learning

When researching conceptual understanding, science education scholars often contrast meaning-making and rote learning. One of the main contrasts is that, unlike rote learning, meaning-making tasks can be anchored to relevant concepts in the cognitive structure (Ausubel, 1963; Belouahem, 2020; Bhattacharya, 2022;

Winstead, 2004). However, the contrast between rote learning and meaning-making gives the impression that they are dichotomous approaches, but they are better likened to different points in a continuum (Ausubel, 1963; Grove & Bretz, 2012), and so will have aspects that are close to each other, or even overlap. Meaning-making is different from rote learning because, in rote learning, the learner has to memorise concepts by heart, also dubbed “drill and practice”, compared to meaningful learning where learners seek to understand concepts and not just memorise them (Belouahem, 2020).

Another aspect that differentiates meaning-making and rote learning is the concept of retention. In this case, retention is the continued possession of conceptual understanding, and not just about recalling basic science facts. Meaning-making is considered to improve retention as compared to rote learning (Ausubel, 1963) by virtue of internalising information instead of simply memorising it (Belouahem, 2020). By forming connections between what is taught in class and real life, learners can understand the content better, which improves the retention of the information, even long after an exam has passed. Briscoe and LaMaster (1991), and more recently, Suwiknyo (2023) found that many students do not retain concepts after an exam because they do not connect those concepts with real-life experiences. Meaning-making can be leveraged to counteract the poor retention which results from rote learning (Belouahem, 2020; Torlaklı, 2019; Vallori, 2014) and, thus improve learner performance in science classrooms.

Materials that are learned by rote are isolated entities, only relating to cognitive structure in an arbitrary and verbatim way which prevents significant relationships

such as correlation and derivation from forming (Ausubel, 1963; Suwiknyo, 2023). This lack of connection between concepts diminishes the transferability of material that is learnt by rote. If the learned material cannot be subsumed, it is automatically part of rote learning, which pushes the learner to find a solution to a problem or learn content verbatim, which isolates the learned information. This isolation is because the material is not rooted in cognitive structure and is therefore prone to being forgotten.

Forgetfulness is a natural part of meaning-making (Ausubel, 1963; Suwiknyo, 2023). As such, it is not a given that knowledge the learner has learned meaningfully is never forgotten (Agra et al., 2019; Reid & Ali, 2020), but is easier to recall because the learner has made links to other 'pockets' of knowledge. When meaning-making occurs, the new information finds anchorage in a conceptual system that is already stable, increasing the retention span of the information (Ausubel, 2012; Suwiknyo, 2023). The retained information is not specific but is characterised by principles and applications, especially in science and mathematics (Ausubel, 1963), and this retention can last for months, or even years. If the original information is forgotten, it is easy to relearn if it was learned meaningfully (Agra et al., 2019). The main issue at hand in gaining a grasp of a subject is how to counteract forgetting, an inevitable process that is a hallmark of meaning-making (Ausubel, 2012). To successfully do this, the subsumption of new content must facilitate both meaning-making and retention (Ausubel, 1963; Belouahem, 2020). Paradoxically, this meaning-making provides the basis for forgetting (Ausubel, 1963), but as previously stated, relearning will not be difficult because the generalisations and principles of the concept remain.

Multiple factors show that meaning-making is more effective than rote learning. These include the idea that it is easier to assimilate new information than it is to memorise it verbatim, while reducing learning time (Agra et al., 2019; Ausubel, 1963). This is because the new information is recognised as not completely isolated and new, and is connected to prior knowledge. By learning underlying principles, as opposed to verbatim memorisation, tasks are easier to retain and transfer (Ausubel, 1963; Danielak et al., 2014). An important factor that affects how long a learner retains the concepts of a potentially meaningful lesson is how much the learner can discriminate the new concepts with the system that subsumes it (Ausubel, 1963; Danielak et al., 2014). If a learner cannot discriminate between concepts, meaning-making cannot take place (Ausubel, 1963). This has led to scholars suggesting different strategies to maximise meaning-making.

2.3 Strategies for achieving meaning-making

In the previous section, I defined the concept of meaning-making and discussed how it is different from rote learning as well as its indicators. I also noted that meaning-making needs to be attained by learners as it is a way through which they can understand science concepts conceptually. The strategies that can lead to meaning-making have been reported in literature. These strategies include the use of models (Chiu & Lin, 2019; Halloun, 1996; Jonassen & Strobel, 2006), concept mapping (Novak & Gowin, 1984), and active retrieval (Fiorella, 2023; Karpicke, 2012, 2017). I discuss these strategies below.

Halloun (1996) suggests that when learners are presented with science lessons in the form of models, they learn meaningfully. Chiu and Lin (2019) support this suggestion and further posit that models are necessary for the twenty-first-century learner. These models can either be simulated models (Nevanpää & Law, 2006) or involve the use of inanimate objects (Ramey-Gassert, 1998) to help learners understand the concept of population ecology (specifically calculating population size). This strategy of modelling, along with active retrieval, does not have as much scholarly support as the concept mapping strategy.

According to Vallori (2014), concept maps are “represented hierarchically with the most inclusive and most general concepts at the top of the map and the more specific concepts are arranged hierarchically below,” (p. 4). This allows the learner to relate concepts together, and understand how the more specific concepts differ from each other, and other concepts in a different category (Romero García et al., 2017). (Novak, 1990) and other researchers (Cañas & Novak, 2014; Romero García et al., 2017; Safdar et al., 2012) showed that concept maps can capture what children know, and show how they modify the maps to fit their conceptual understanding of different concepts (Novak, 1990). Although concept maps are very useful tools, they do not work in isolation. By combining the use of concept maps with collaborative learning, the teacher can encourage the learners to carry out tasks using a new approach (Khoza & Maseko, 2024; Vallori, 2014), thus using the concept of active retrieval of information. Although this study deals with teacher talk moves, concept mapping can be used as an initiative to engage learners in classroom discussions.

To change their perspective, and therefore how they handle and internalise information, the learners must be open to different perspectives that challenge what they already believe (Fiddler & Marienau, 2008). To create new understanding, learners must therefore be aware of their own perspective and its limitations, if they want it to be changed. This requires the learner to understand the importance of thinking for themselves, which will assist them in their understanding and retention of information, which in turn assists them in their learning. Therefore, meaning-making requires the learners to question their assumptions and beliefs, which requires reflection (Fiddler & Marienau, 2008). This is supported by the findings of Grove and Bretz (2012) that meaningful learners are meta-cognitive in their learning processes.

2.4 Indicators of meaning-making during interactions

Since the focus of this study was not on learners, my definition of meaning-making leans towards its indicators during interactions, and how teachers make use of discursive moves to make opportunities for these indicators to appear transparent during interaction. For this study, I combined the definition of meaning-making by Ajayi (2008) with those of Vygotsky (1978) and Zittoun and Brinkmann (2012). The latter compensates for the ignorance of learners' experience and previous knowledge in the first two definitions. Two indicators of meaning-making emerge from these definitions. The first is learners internalising the new information being taught to create their own meaning about population ecology. The second is building knowledge either by themselves or with the help of each other. I describe these indicators below.

Regarding the first indicator, one can observe meaning-making by looking at how learners draw from their prior knowledge and incorporate the new knowledge in response to a teacher's prompt. These prompts are regarded as discursive moves in this study. Prior knowledge is defined by Dochy et al. (1999) as the entirety of a learner's actual knowledge that is already present before a learning task. In this case, the learning task is the topic of population ecology. Sources of this prior knowledge include prior teaching and everyday experiences/knowledge. As part of the meaning-making process, the learner brings together ideas that they already know and new ideas, and this is brought forth by talk (Mortimer & Scott, 2003).

For the learners to internalise and make meaning out of new knowledge, they must work on these ideas. Wong (2015) proposed that characteristics of meaningful learning include that the learning is active (Ajayi, 2008), constructive (Freire, 2000), intentional, contextual, cooperative and conversational (Saglam, 2022). This is reflective of the assertion made by Shuell (1990, p. 3) that meaningful learning is an "active, constructive and cumulative process that occurs gradually over time." Ignelzi (2000) and Van den Heuvel et al. (2013) echo this assertion.

Meanings are developed through language and other forms of communication in the classroom (Scott & Mortimer, 2005). This is supported by Bakhtin's definition of meaning-making, which says that it includes how the development of past experiences come together with present actions and information in a complex interaction, which tends to be dialogic (Bakhtin, 2010). As such, in this study, to see whether learners are making meaning, I was also looking at how learners

draw from their prior knowledge to internalise the population ecology content during classroom talk.

The second indicator of meaning-making is how learners build knowledge through their responses to teacher talk moves. To make sense of what is being taught, the learners have to compare and contrast their views with the content in the science classroom (Danielak et al., 2014; Mortimer & Scott, 2003). Meaning-making requires participants to undergo a process in which they compare and check their understanding against ideas being shared on a social plane, and this process demands self-evaluation (Danielak et al., 2014; Kottalil, 2009). Meaning-making is controlled by two forces which work in opposition to each other: centripetal, which works to homogenise and centralise meanings, and centrifugal, which has the purpose of dispersing and decentralising meaning using a dialogic approach (Beraldo et al., 2022; Mortimer & Scott, 2003). This approach requires learners to lay down a set of their own answering words to those of the teacher (Scott & Mortimer, 2005a). One of the ways for the teacher to foster the learners' meaning-making process is through the use of talk moves (Howe et al., 2019; Mortimer & Scott, 2003; Strat et al., 2024). Thus, my study looks at how teachers use their moves to foster meaning-making when teaching population ecology.

Shuell (1990) proposed that meaningful learning occurs in phases, and he identified three: initial phase, intermediate phase, and terminal phase (Karpicke & Grimaldi, 2012; Mayer, 2002). These phases progress from the learner knowing nothing about the concept, to demonstrating their mastery over the concept. In the initial phase, the learner encounters new information that they learn and memorise in isolation. The first phase of meaningful learning is in the realm of

rote learning, and if the learner cannot make meaning of the information they received, it remains as facts in isolation. For the second phase of meaningful learning to be achieved, the learner gradually starts to see the connections and relationships between the isolated information they memorised and recall (Karpicke & Grimaldi, 2012; Schuh, 2016). This phase is important because this is when the learner can manipulate the new knowledge in different ways and receive feedback for it, which offers the learner an opportunity to reflect on the knowledge and thus move on to the last phase of meaningful learning. The last phase, the terminal phase, is more concerned with whether the learner can demonstrate their knowledge of the concept (Shuell, 1990).

This knowledge now becomes a habit and is entirely ingrained in the learner's schema, signifying the achievement of meaningful learning. The boundaries between phases are not well-defined but are more gradual and overlapping (Grove & Bretz, 2012; Shuell, 1990). The process begins with rote learning and ends with an effortless demonstration of the knowledge; this implies that learning is a spectrum that begins with rote learning and has meaningful learning at the opposite end of that spectrum. These phases of meaningful learning can be facilitated through the teacher's use of talk moves to establish a dialogic discourse in science classrooms (Khoza & Msimanga, 2022).

2.5 Science classroom talk and discourse

In the previous sections, I discussed the definitions, strategies, and indicators of meaning-making. In this section, I discuss how classroom talk influences meaning-making, and I go into detail about how this occurs in the science classroom.

2.5.1 Classroom talk

To understand the role of teacher talk in influencing learner meaning-making, it is important to have a look at the overarching concepts within which teacher talk exists. These concepts are classroom talk and discourses.

Science classroom talk has been conceptualised in various ways, and different terms have been coined for it. Some of these terms include science talk and talking science. Lemke (1990) used the term talking science to explain the sociolinguistics of science classrooms. Her focus was more on the language aspects of science classroom interactions by studying ways in which teachers and learners talk about science. This has gained a lot of attention in science education where researchers looked at science as a new language and how learners talk about concepts of science coming from different language backgrounds.

For example, Thurs (2007) emphasised that science has a unique language, requiring ways of talking such that concepts can be internalised. Thurs's (2007) argument is similar to that of Ash (2007), who argued that social practices and cultures influence how learners use this language to understand natural phenomena. Some scholars conceptualised classroom talk in terms of communication, including non-verbal communication such as gestures (Roth, 1994). This conceptualisation is usually linked to the multimodality of teaching and learning science. Such scholars argue that talking science involves the use of different approaches to make sense of science concepts. For example, Pahl (2009) investigated the link between learners' talk and their multimodal text. Mitchell (2009) looked at classroom talk from the perspective of teacher

behaviours and pedagogical approaches. In this case, classroom talk was conceptualised from both verbal utterances and non-verbal cues. Recently, many studies have examined classroom talk practices by analysing teacher and learners' utterances (Bansal, 2018; Khoza & Msimanga, 2021). Such studies seem to confine classroom talk to verbal utterances only.

As such, science classroom talk in this study does not only mean verbal utterances but also the use of different modes of representation that have the potential to drive how both the teacher and learners talk about science content. This communication is driven by teacher talk (Chapin & Anderson, 2013), which in turn drives learner talk (Sedláček & Šed'ova, 2020), and eventually comes back to the teacher to further the interaction in the classroom (Pimentel & McNeill, 2013; Tytler & Aranda, 2015), thus producing an interaction pattern that exhibits a specific discourse.

2.5.2 Discourse in science classrooms

Scott and Mortimer (2005) introduced a framework for collecting and analysing talk in the science classroom. In their framework, they listed the teaching purpose, content, communication approaches, patterns of discourse, and teacher interventions as lenses through which researchers can investigate classroom interactions. Of particular interest to this study is the component of communicative approaches, perceived as discourses as reported in other literature (Khoza & Msimanga, 2022). There are two main discourses, namely dialogic and authoritative (Scott & Mortimer, 2005). The relationships in this framework are shown in Figure 2.1 below.

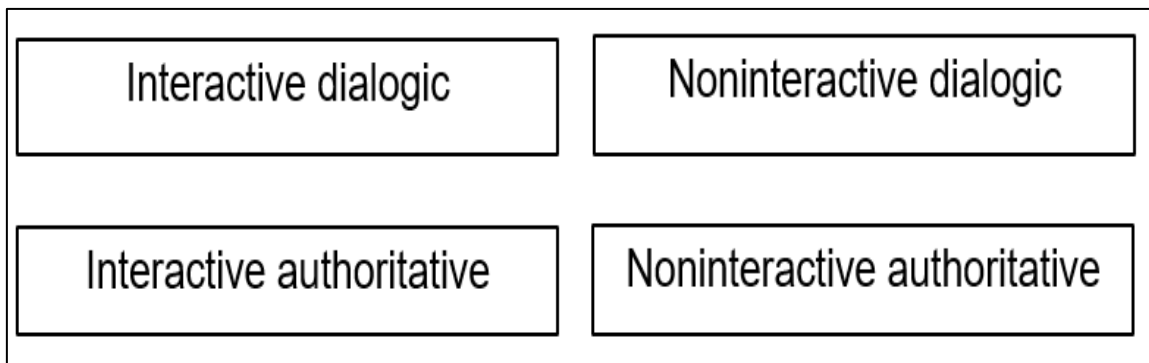


Figure 2.1 Dialogic and authoritative quadrats (Scott & Mortimer, 2005, p. 35)

The authoritative discourse puts the teacher at the centre of the interaction sequence (Wang & Ma, 2019), whereas the dialogic discourse is more inclusive of the learners (Chin, 2007). In an authoritative classroom, learner talk is limited in both quality and quantity, and the learners' contributions are not sought out, as they are just reciting what they have been taught by the teacher (Ajayi, 2008; Lehesvuori et al., 2019). Recitation of science concepts discourages learners from participating in the conversation. Conversely, dialogic discourse invites learners to join in on the conversation, to argue their points, and to justify their ideas (Ajayi, 2008; Lehesvuori et al., 2019). Dialogic discourse opens an opportunity for the teacher to address any misconceptions and incorrect ideas about the topic of discussion (Chin, 2007; van der Veen et al., 2018). Teachers whose learners achieve the learning outcomes tend to use the dialogic approach to gauge the knowledge of the learners to guide the learners' activity, as well as to assess the learners' level of understanding regarding a topic (Mercer & Littleton, 2007).

Indeed, Sedláček and Šedřova (2020) found that in classrooms where the dialogic approach was used, learners were more engaged with the lesson and performed

better than where the most prominent voice in the classroom was that of the teacher. This, however, does not mean that the authoritative approach is without merit. It consolidates the knowledge that the learners were sharing with each other and emphasises the points that the learners should take note of as it focuses on the voice of science (Bossér & Lindahl, 2021).

Despite the plethora of literature that displays the authoritative approach in a poor light, this approach is not only useful but essential for the science classroom. Although technical or scientific talk can cause learners to feel alienated (Saglam, 2022), scientific talk is a requirement for the science classroom if the voice of science is to be heard. This is because according to Saglam (2022), scientific disciplines have their own language, and this language cannot be compromised in the science classroom, as it may prevent learners from fully grasping the concept being taught, or they may understand the concept but not have the terminology with which to explain that concept (Khoza, 2024).

In a study by Saglam (2022) that compared students' comprehension of written talk, all the students preferred the dialogic approach because the words in the dialogic talk used were from daily life, whereas the authoritative approach used technical language. The daily language may help with comprehension but should not replace the scientific terminology that is necessary in a science lesson and science classroom. This is especially true for the Life Sciences classroom because even if learners comprehend the concepts being taught using everyday language, learners are not awarded marks if they do not include the related scientific terminology in their answers when writing a task (Department of Basic Education, 2023d). The authoritative discourse helps the teacher direct the lesson

because if learners are left on their own to discuss a concept, they may exchange ideas about said concept without learning anything substantial regarding the syllabus (Mortimer & Scott, 2003). This direction works to give learners the essential knowledge they require for learning a concept or topic (Bansal, 2018). It is also important for reviewing what has been covered in a lesson, and to bring the lesson to a close.

The authoritative approach is not limited to the teacher being the main speaker, but, in the science classroom, the verbal exchange is authoritative only if the voice of science is heard, even if learners are participating in the classroom talk (Mortimer & Scott, 2003), because the intent behind the teaching of scientific concepts is for the learner to develop knowledge and understanding of science (Department of Basic Education, 2011b), which cannot happen without science talk in the classroom.

One of the specific aims of Life Science teaching is for learners to be able to “describe concepts, processes, phenomena, mechanisms, principles, theories, laws and models in Life Sciences” (Department of Basic Education, 2011a, p. 13). This specific aim requires the learner to know the language of science and requires the authoritative approach. This science talk is a conversation that includes the voice of science and becomes a collaboration between the participants of the talk (Wong, 2015), who in this case are the learners, to exchange knowledge and ideas using the language of science. Wong (2015) warns against oversimplifying ideas to make them palatable to learners because it can cause misconceptions of science concepts (King, 2010). Authoritative discourse in the classroom cannot work in isolation but is the catalyst for dialogue

in the classroom (Bansal, 2018; Scott et al., 2006), with learners actively participating in the creation of knowledge (Kim, 2022).

The dialogic and authoritative discourses can further be split into two aspects: the interactive and non-interactive aspects. The interactive aspect invites learners to participate in the talk, especially when paired with the dialogic approach, whereas the non-interactive discourages and excludes learner participation (Chin, 2007), which is exacerbated when paired with the authoritative approach. The success of the interactive approach depends on the learners' willingness to think about the topic. When they do so, they are empowered to engage in classroom conversations to share their own thoughts about the topic with others and get feedback on the correctness and accuracy of their ideas, as well as on their level of understanding of the topic of the lesson (Sedláček & Šed'ova, 2020). The implication of this is that the level of participation of the learners in classroom talk dictates the effect of the classroom talk on the learner, that is, how well the learner grasps the topic that was discussed. This is supported by research that found that dialogically oriented questioning from the teacher is associated with higher cognitive responses and contributions from learners (Soysal & Yilmaz-Tuzun, 2021). Based on these findings, it appears that the dialogic interactive approach leads to higher cognitive thinking from learners, which leads to learners understanding the concepts easier than when the classroom talk is centred around the teacher. Indeed, Scott and Mortimer (2005) found that when learners interact in a dialogic classroom talk, the quality of their contributions is richer than when they are in a teacher-centred, authoritative classroom that only amplifies the teacher's voice.

Wertsch (1991) claims that meaning-making is a dialogic process. The notion of a dialogic discourse to facilitate meaning-making is supported by Saglam (2022), who asserts that dialogic teaching encourages learners to contribute their viewpoints about scientific phenomena (Mortimer & Scott, 2003), helping not only them, but others, to situate their knowledge into their own real-world experiences (Gee, 2003; Wong, 2015). Using the dialogic approach, the teacher attempts to get learners to talk and eventually think about the implications of what is taught in a lesson (Mortimer & Scott, 2003), allowing learners to internalise and apply the knowledge to their own lives and experiences (Saglam et al., 2015). There might be limited problem-solving if the teacher does not make the science ideas more accessible to the learners, meaning easier to engage with and therefore internalise (Chin, 2007). The process of internalisation is dependent on the teacher discerning what talk moves to use, and when to use them (Chin, 2007). Soysal and Yilmaz-Tuzun (2021) proposed that teacher talk moves are dependent on the topic being taught, implying that the teacher must use a different strategy when they use talk moves for different topics that they teach and that a single strategy is not suitable for every topic.

2.6 Talk moves in the science classroom

In the previous section, I discussed literature on classroom talk and discourses. I have further discussed how patterns of interaction in classroom talk can define certain discourses in science classrooms. In this section, I argue that classroom science talk is driven by the talk moves of the teacher, as they lead the conversation in the classroom. I present literature on various types of talk moves.

2.6.1 General literature on teacher talk moves

In classroom talk, teacher questioning is an important and prominent feature (Chin, 2007). Teacher questioning can jumpstart learners' thinking, which will allow them to make contributions. The teacher can then use these contributions to ascertain learners' understanding and pinpoint where they are lacking (Chin, 2007). When the teacher asks learners to share where they misunderstand the topic, the other learners can respond in a way that allows the learner in question, as well as the rest of the class, to develop their own understanding (Mercer & Littleton, 2007). When learners understand, they feel more confident in sharing their ideas, which helps not just the learner sharing the ideas, but the other learners as well. This can subsequently accelerate their learning process, which leads to better results when formally assessed (Sedláček & Šedřova, 2020).

The role of teachers in cultivating discussion is a crucial part of classroom science talk, and some of the talk moves and prompts that teachers utilise affect the classroom science talk. If not prompted, learners may respond with short answers and not elaborate if the teacher does not probe any further (Pimentel & McNeill, 2013). Molinari et al. (2013) argue that open questions from teachers lead to complex responses from the learners, which in turn lead to the teacher probing for more complex and elaborative contributions from the learners, resulting in coherence in the dialogic process. However, this narrative is contested by the findings of a South African study by Khoza and Msimanga (2021), who found that it was not necessarily the case that close-ended questions lead to little interaction as a result of using lower-order rejoinder moves. Conversely, they found that it is not just the open-ended prompts that lead to full content engagement with the

learners. The Khoza and Msimanga (2021) study was conducted in the subject of Physical Sciences, so it is unknown if similar results would be obtained for another subject. In another study focusing on the basics of genetics, Buma and Nyamupangedengu (2020) established that the most dominating teacher talk moves that encouraged student participation were initiating and rejoinder moves, which positively affected students' ability to make meaning out of the content. Therefore, talk enables the teacher to support learners' meaning-making process (Mortimer & Scott, 2003), which uses language as its dominant mode of content delivery.

Boyd and Rubin (2006) found that to get learners to make contributions, teacher questioning must rely on the previous responses and contributions of the learners. These contributions serve as a foundation on which other learners can build upon to improve their own understanding. Chin (2006) implies this by arguing that during a class discussion, the teacher must be flexible. This flexibility accommodates the responses of learners based on previous contributions from the rest of the class. The teacher then acknowledges the learner's contribution and tailors their questioning accordingly. The teacher does this by using comments that expand on, justify, and add more information to the learner's response to continue the conversation (Hardman, 2019), allowing learners to contribute more. This implies that the more learners engage with the topic of the lesson and make more contributions that others can use, the better the learners will perform.

During recitation, the teacher uses the IRE/F method for talking (Chin, 2007). This type of method does not inspire the learners to actively think about the content.

The learners simply recite what the teacher has said back to them (Hardman, 2019), with brief answers. The teacher then asserts whether the learners are correct or not by evaluating their responses. This recitation does not invite learners into the conversation and stifles their desire to reason and contribute more meaningfully to the conversation.

However, recitation has its merits in checking what learners remember regarding the topic of the lesson (Michaels & O'Connor, 2015), but it prevents learners from thinking critically and making contributions, and therefore only knowing the surface level of the content, which does not encourage deep thinking on the topic. This in turn bars them from having a conversation and listening to each other's contributions to build complex arguments with one another (Michaels & O'Connor, 2012). Building complex arguments is particularly important in science classrooms as it challenges learners' ideas as well as extending their thinking of science concepts. Therefore, it is one of the desired strategies when teaching science.

Argumentation and reasoning encourage learners to engage with each other's ideas constructively, helping them in their understanding and problem-solving skills (Hardman, 2019). This cannot happen without the learners putting their ideas forward in the class to get feedback from other learners. The implication of this is that this type of engagement requires and reinforces trust dynamics in the classroom since learners take risks when contributing to the classroom (Michaels & O'Connor, 2015). The extent of learners' contributions during a lesson can indicate the quality of the classroom talk (Hardman, 2019). However, Khoza and Msimanga (2021) argue that this is not always the case. Wood (1994) suggests

that reducing the number of questions increases learners' contributions during classroom interactions. While the nature of learners' contributions to the classroom can indicate the quality of talk taking place, it is the teacher's responsibility to drive this talk.

Teachers use multiple avenues in the classroom to direct the conversation. As discussed in an earlier section, teacher talk moves are categorised into two main groups: initiation moves and rejoinders. Initiations start the conversation, while rejoinders work to sustain engagement from the learners.

2.6.2 Initiation moves

Although classroom talk is mostly directed and started by the teacher, learners are also capable of starting classroom talk by asking their questions. The practice of providing opportunities for learners to ask questions, however, does not diminish the importance of the initiation move as it invites learners to contribute and almost ensures engagement from the learners. Therefore, learners' engagement depends on the initiation moves that the teacher uses because the teacher controls what is discussed in class, and even when learners can contribute to the classroom discourse (Rachomas & Trakulkasemsuk, 2014) through the use of a variety of initiation moves.

Ginting (2017) provides ten categories of initiation moves: a) teacher elicit, which entails the teacher asking an initial question; b) teacher inform move is where the teacher shares ideas and information with the learners; c) teacher direct, where the teacher gives learners instruction to perform a task; d) listing is when the teacher withholds evaluation of responses to get more answers from the learners;

e) re-initiation i, in which there is no response from the learners and the teacher rephrases the original question; f) re-initiation ii, where the teacher rephrases the original question when they receive wrong answers from the learners; g) checking move is used when the teacher checks on the learners; h) the reinforce move corrects any misunderstanding that the learners show; i) the repeat move is when the teacher repeats their initial question; and j) the bound initiation move is used to repeat a question when there is no response. These categories overlap with each other, and some can be grouped together. For example, re-initiation i and re-initiation ii serve the same purpose: to rephrase the original question when the teacher does not get the appropriate response. The same is true for the repeat and bound initiation moves.

Correnti et al. (2015) grouped initiation moves into three categories: the launch, literal, and providing information moves. The launch moves are in the form of open questions, to generate initial thinking from the learners (Lee & Glass, 2021). The literal move is in the form of closed questions and seeks specific answers (Lee et al., 2024). The providing information move gives learners information or instructions so that they can perform a task or answer a question. Therefore, these moves serve different purposes in science classrooms. For example, there would be a time when a teacher seeks to open up a discussion, and a different time when the goal is to provide the authoritative science content. These moves allow teachers to drive interaction based on the purposes of the lesson. I argue that this categorisation by Correnti et al. (2015) is more fitting for my study because it simplifies the categories by consolidating them into three categories. For example, the teacher's direct and inform moves can both be placed under the

providing information move. Additionally, some of the initiation moves that are described by Ginting (2017) are in response to learner engagement and I argue that they belong in another category. This category is the rejoinder move and is discussed in the next section.

To get learners to contribute following the teacher's initiation move, they must be given sufficient time to think about and formulate their responses. This period immediately following the teacher's initiation from the teacher and before the learners' response is described as wait time (An & Childs, 2023). This wait time allows for better learning because learners are given the chance to reflect on the questions posed to them (Ingram & Elliott, 2016). Wait time extends to the teacher allowing the learners to find their own answer and voice it out without being interrupted by the teacher, including the teacher not giving the learners the answer before they can do so (Mesa & Lande, 2014). This allows the learners to grapple with finding a solution on their own, which in turn allows them to grow in their understanding. In this study, I argue that wait time is crucial in the meaning-making process of learners because they can mentally engage with the content by actively participating (Kang, 2017) and give meaningful contributions, to which the teacher responds in the form of rejoinders.

2.6.3 Rejoinders

Teachers have to constantly reflect on the occurrences in the classroom and react to them accordingly (Khoza, 2023), and this includes classroom talk. Khoza (2023) argues that the teacher should carefully consider the learners' contributions to probe them further. By probing the learners, the teacher opens the classroom talk, which invites the learners to give further input on the

conversation that is taking place in the classroom. This participation is dependent on the moves that the teacher uses. Some talk moves that teachers use can limit learner engagement, while others seek to increase it (Mesa & Lande, 2014). These moves are how the teachers respond to learner contributions. In the IRE/F model, the teacher's move in response to learner contribution is solely for giving learners feedback on the correctness of their answers, which closes the conversation and prevents dialogue in the classroom (Webb & Jones, 2009). This model also does not expose learners to difficult questions, preventing them from critically engaging with the content (Mesa & Lande, 2014). Due to these restrictions perpetuated by the IRE/F model, science teachers are moving beyond this interaction pattern to create a space in the classroom where learners can give their input in classroom talk (Khoza, 2023) without being limited to just correct and incorrect answers to the teacher's questions. This freedom allows the learners to give their input more organically because the teacher invites them to participate.

The moves that invite learners to meaningfully participate in classroom talk having initiated a discussion, as previously mentioned, are rejoinders and were conceptualised into multiple categories. Correnti et al. (2015) conceptualised these rejoinders into three categories: repeat, uptake, and connection. The repeat move is used by the teacher to repeat what the learner has said, the uptake rejoinder extends learner contributions, and the connection move is used to make links between concepts. These three categories are limiting in their descriptions of how the teacher responds to learner contributions. One such limitation is that

these moves imply that there is little variation in the learners' responses, and therefore these descriptions reduce the complexity of classroom talk.

For example, the uptake move is used to extend learners' contributions, but this can be done in multiple ways, such as asking the learners to elaborate, justify or even rephrase their contribution in scientific language; therefore, these categories are too broad and lack specificity. Tytler and Aranda (2015) categorised rejoinder moves into multiple categories as well, which are more descriptive than those of Correnti et al. (2015). The categories are eliciting and acknowledging; clarifying moves; and extending learner contributions. These moves also include inviting other learners to give their input on the contributions of their classmates and are not limited to teacher-learner exchanges. These categories also have their own subcategories to describe further the type of rejoinder used by the teacher.

The eliciting and acknowledging moves include soliciting ideas and contributions from learners as well as encouraging contributions to the question or probe that the teacher used in their initiation move. It is used to get learners' various answers to what they think about the concept at hand (Janah et al., 2019). The clarifying moves are designed to focus learner input to position them to make meaning by using methods that range from reframing questions to revoicing learner input (Khoza, 2023) into more scientific language. The extending move is used to challenge learners on their ideas, directly or indirectly, to get them to justify and defend the contributions and think of them in another context (Tytler & Aranda, 2015), encouraging the learner to think more deeply about a concept (Janah et al., 2019). The use of these rejoinder moves in the science classroom has an

impact on how classroom interaction unfolds (Khoza, 2023) including the contributions that the learners give. These contributions from the learners can be brief or extended (Hardman, 2019), which requires a response from the teachers. This creates a dialogue in the classroom, which the teacher uses to uncover learners' thoughts and encourage them to explore those ideas (Webb & Jones, 2009).

In summary, a classroom that is conducive to meaning-making is one that is open and where the teacher encourages learner contributions and further probes learners to share their ideas and defend them instead of just giving the learners feedback on the answers that the learners give to the initial question. Rejoinders are useful in this regard in that they open up dialogue in the classroom further than the IRE/F triad. Both the initiations and rejoinders are important when teaching problematic topics like population ecology.

2.7 The teaching and learning of population ecology

In this section, I unpack the topic of population ecology as a topic in the South African curriculum and its progression regarding its teaching and learning. I then discuss the misconceptions in this topic and then talk about the strategies that are used in this topic.

2.7.1 Population ecology as a topic in the South African Life Sciences curriculum

Kuechle (1995) posits that ecological principles should be included in the curriculum as they form an important component of biology. This incorporation of concepts is necessary because ecological concepts such as population ecology, although one of the more difficult concepts in biology, are still important (Nevanpää & Law, 2006). The National Senior Certificate diagnostic report

(Department of Basic Education, 2021c) supports this claim, and shows that learners struggle with ecological concepts.

The Life Sciences Curriculum and Assessment Policy Statement (CAPS) document (Department of Basic Education, 2011a) specifies that one of the purposes of studying this subject is to develop scientific knowledge and understanding to answer questions about the natural world, thereby laying a foundation of being a responsible citizen towards the environment. The second purpose is to learn skills in a way that supports creativity and confidence for learners to think objectively and use reason when learning science. Therefore, teacher talk moves can facilitate these processes for learner engagement.

The population ecology topic taught in Grade 11 includes population size, interactions in the environment, social organisation, succession, and the human population, which is also taught in Grade 10 Geography (Grussendorff et al., 2014; van der Westhuizen & Golightly, 2018). Some of these themes have their foundations in previous grades, especially Grade 8 Natural Sciences and Grade 10 Life Sciences. In Grade 8, learners are introduced to the concept of ecology under the theme of interactions and interdependence in the environment (Department of Basic Education, 2011b). Under the concept of balance in the ecosystem, the learners are briefly introduced to the idea of carrying capacity and density dependence factors such as natural disasters and climate change. In Grade 10, the strand of environmental studies is introduced (Department of Basic Education, 2011a; Grussendorff et al., 2014). Although there is no direct link to Grade 11 population ecology, there is a link to Grade 8 concepts of biotic factors and grades 9 and 11 nutrition.

In Grade 11, the topics that are taught and are not in the strand of environmental studies are all taught in terms 1 and 2. These topics, being the diversity of living organisms and the processes in those organisms, relate to one another (Grussendorff et al., 2014). There is no transition between the above concepts and population ecology, which can make the topic seem out of place. Thus, population ecology may seem like an afterthought, a topic that did not fit anywhere else in the curriculum, and this may even imply that it does not belong in the content of Grade 11 Life Sciences. The lack of linking population ecology with other topics in Grade 11 and Grade 10 may further alienate the topic.

The timing of the teaching of population ecology is echoed in the Life Sciences textbooks, whose structures are dictated by the CAPS document (Department of Basic Education, 2011a), which places the topic in the last strand of environmental studies. Biology textbooks that were evaluated by Hovardas and Korfiatis (2011) present ecology by describing naturalistic activities, but not presenting the content as scientific. There is also little integration of this topic within many biology textbooks studied (Kuechle, 1995). A simple example of this integration would be in the section on biodiversity of microorganisms and their symbiotic relationships with other living organisms. This poor integration can detract from the understanding that population ecology is a scientific concept and can reduce its importance. Kuechle (1995) further argues that textbooks must focus on biological concepts throughout the textbooks instead of only using a compartmentalisation approach, which is not disadvantageous, but with the integration of other approaches, can prevent isolation of concepts. Some of the ecological concepts used in teaching practice tend to be out of date, may

represent incorrect science, and can even be found to not be scientific at all (Hovardas & Korfiatis, 2011). An example of a prevailing erroneous concept is the idea of the 'Balance of Nature', as argued in Chapter 1.

2.7.2 Taught misconceptions in the topic of population ecology

Misconceptions threaten the learning that takes place in the classroom (Rogayan Jr & Albino, 2019), and not addressing them fulfils that threat. According to the 'Balance of Nature' metaphor, nature is in a constant, balanced state, that is only upset by human intervention and interference (Hovardas & Korfiatis, 2011). This idea enforces misconceptions about ecology and gives the impression that nature will always balance itself to a default state and any deviation from this default state stems from human activity and will lead to the ecosystem collapsing. Because of its prevalence, learners believe in the 'Balance of Nature' metaphor, which can impede their acceptance of more complex concepts such as predator-prey interactions, which can lead to population extinctions (Hovardas & Korfiatis, 2011). The 'Balance of Nature' idea also does not consider other concepts such as density-dependent factors, only the disturbances that are attributed to humans. This metaphor also reinforces the traditional teaching of succession, that it is caused by deforestation, which is a human activity. Hovardas and Korfiatis (2011) argue that using a critical approach to teaching ecology should include evaluating ideas such as 'Balance of Nature', which have been taken for granted as true, as such evaluations can benefit science education.

Rogayan Jr and Albino (2019) conducted a study that found that there is a prevalence of ecology misconceptions in learners. These misconceptions include concepts such as predation and relationships and interdependence between

different species in the ecosystem. These findings echo those of Butler et al. (2015), who found that misconceptions are not limited to those mentioned above, but include ecological niches, and carrying capacity. These misconceptions are easily perpetuated because even pre-service science teachers have misconceptions about concepts of ecology (Butler et al., 2015; Cardak & Dikmenli, 2016). These teacher misconceptions further endanger learners' understanding of the topic of population ecology, because if their teacher has misconceptions, they will never be addressed and corrected.

2.7.3 Teaching strategies used in population ecology

The success of the science classroom includes learners understanding ecological succession (Schmidt et al., 2022). Understanding this concept will help learners to grasp how biological systems affect each other. This is important for learners to understand, as it contributes to their scientific literacy. Population ecology is one of the most practical units in ecological dynamics (Berryman, 2020). Because of its practicality, teachers have found methods to teach concepts. The understanding of succession is linked to comprehension of the changing nature of communities within the environment, which conceptualises species interactions (Gibson et al., 1999). Schmidt et al. (2022) found that most high school ecological succession education only involves terrestrial ecosystems, implying that other non-terrestrial ecosystems have different dynamics. This pushes population ecology education to encompass other real-life examples that learners can relate to and draw from the prior knowledge during interactions.

Real-world cases that are easily available are more attractive to learners compared to abstract ideas (Hovardas & Korfiatis, 2011). One way to incorporate

these real-life examples when teaching population ecology is to use experiments (Wallace, 2005). Teachers teach concepts such as population size estimation using the mark-recapture method, with inexpensive apparatus such as beans (Ramey-Gassert, 1998), and crickets (Whiteley et al., 2007) as they are small and abundant. By studying small insect populations such as flies (Prater & Buell, 1968) and crickets (Whiteley et al., 2007), learners feel motivated to learn as this is hands-on work that requires their contributions, which can help them acquire the attitudes and attributes of scientists (Prater & Buell, 1968).

According to Hummer (1980), using a small phytoplankton population can help learners link different factors in the environment to population fluctuations. In this way, teachers ensure that learners are participants in their learning. These investigations ensure that learners engage with the content in a real-world context (Ergazaki & Ampatzidis, 2012), which can potentially lead to learners being able to relate to and understand, the content better. Another strategy is to use a modelling tool to teach concepts of carrying capacity, ecological niche, and migration patterns.

Gibson et al. (1999) suggest that the goal of long-term field experiments is to empower learners to be ecologically literate by doing hands-on work. This claim, however, is not supported by their findings, as despite asking learners to give their feedback on their experience in learning succession through experiments, the learners' responses were not mentioned in the article. The suggestion made by Gibson et al. (1999) must be backed with further studies to ascertain that teaching using experiments helps the learners more than the traditional way of teaching population ecology. Schwichow et al. (2016) and Holstermann et al.

(2010) attempt to fill this gap by implying that hands-on fieldwork keeps learners interested in the work. Furthermore, Nevanpää and Law (2006) argue that experimentation is not always possible, even with simple experiments because the processes are tedious. This rings true as experiments using beavers, phytoplankton, and insects can be expensive and time-consuming, which may derail the teaching and learning of other Life Sciences topics as time is limited. Modelling tools also do not work for some concepts such as predation, which calls for the teacher to revert to other ways of teaching this concept.

However, no studies have examined the teaching of this topic when using talk moves for potential meaning-making. Most of the literature used in this section of the literature review is outdated. Newer studies are required to gauge the current climate of the teaching and learning of population ecology, which is what the present study aims to do.

2.8 Teacher experiences with classroom talk

A study by Khoza (2023) showed that South African teachers find it difficult to facilitate class discussions through employing talk, which prevents learners from cognitively taking part in meaning-making, which supports the assertion made by Murphy et al. (2018). Kim (2022) found that learners participated less in class discussions due to the teacher moving on too quickly to the next step in the lesson, which may be an indicator of the teachers' struggle in facilitating discussion, as planning (Fusco, 2012), timing (İnönü & Demircan, 2023) and wait time are important for learners to participate (Kang, 2017). This fast pace not only prevented learners from learning from each other but also prevented the teacher from providing feedback.

Multiple factors affect teachers' use of talk in their classrooms and the extent to which they do so. These factors range from teacher experience to time constraints (Zhang & Lamb, 2024). Khoza (In press) found that experienced teachers were struggling with talk due to their inflexibility regarding their pedagogy and were not critically reflecting on their teaching. This was reflected in how the experienced teachers were authoritative in their teaching approach as compared to the constructive approach of their novice counterparts. This finding was different to that of Coultas (2015), who found that experienced teachers encouraged talk in their classrooms more than novice teachers. These findings point to how teachers' cognition, which includes their beliefs, directly affects their use of talk moves in the classroom (Zhang & Lamb, 2024). Under their cognition, teachers' views of themselves affect how they use talk moves. A participant in the Khoza (In press) study self-identified as a facilitator of knowledge and displayed this by asking questions, a precursor to classroom talk.

Another factor influencing teacher talk is curriculum constraints, which are tied to time constraints. Even as teachers attempt to facilitate talk in the classroom and address misconceptions, the content-heavy curriculum forces them to move on with the lesson quickly in order to cover the content, as one participant in the Khoza (In press) study explained. The curriculum also demands multiple tasks that have to be done during class time, which further burdens the teachers and takes away time they could have used for talk (Coultas, 2015). These tasks include experiments and investigations (Department of Basic Education, 2011a), which, although have the potential of being vehicles for talk, still take time that is not specifically set aside for them in the curriculum. Melnick and Meister (2008)

argue that another demand placed on teachers that impedes their usage of talk due to limited time is tests and examinations. This is reflected in the Life Sciences CAPS document that prescribes content to be taught in nine weeks, not accounting for tests and examinations, in a 10-week term (Department of Basic Education, 2011a).

All these factors affect teachers' agency in how they conduct their lessons. Teig et al. (2019) argue that pressure on teachers is detrimental to their self-determination regarding the instruction that allows the learners to learn freely. This pressure is due to curriculum, time, and management demands on the teachers. The teachers are then prevented from fully exploring ideas they want to implement in their classrooms due to what Coultas (2015) calls teacher busyness. By extension, the teachers are not afforded the time to reflect on those ideas. When time does not allow them to devise new ideas of teaching, which include their use of talk, the teachers cannot teach effectively and by not being able to reflect on their lessons, cannot properly adjust themselves to make learning accessible to learners, which ultimately impacts the learners.

2.9 Conceptual framework

This study is grounded in Vygotsky's socio-cultural theory of learning and development under the broader theory of constructivism. However, I also drew from key concepts that drive the theoretical and methodological aspects of this research (see Figure 2.2 below).

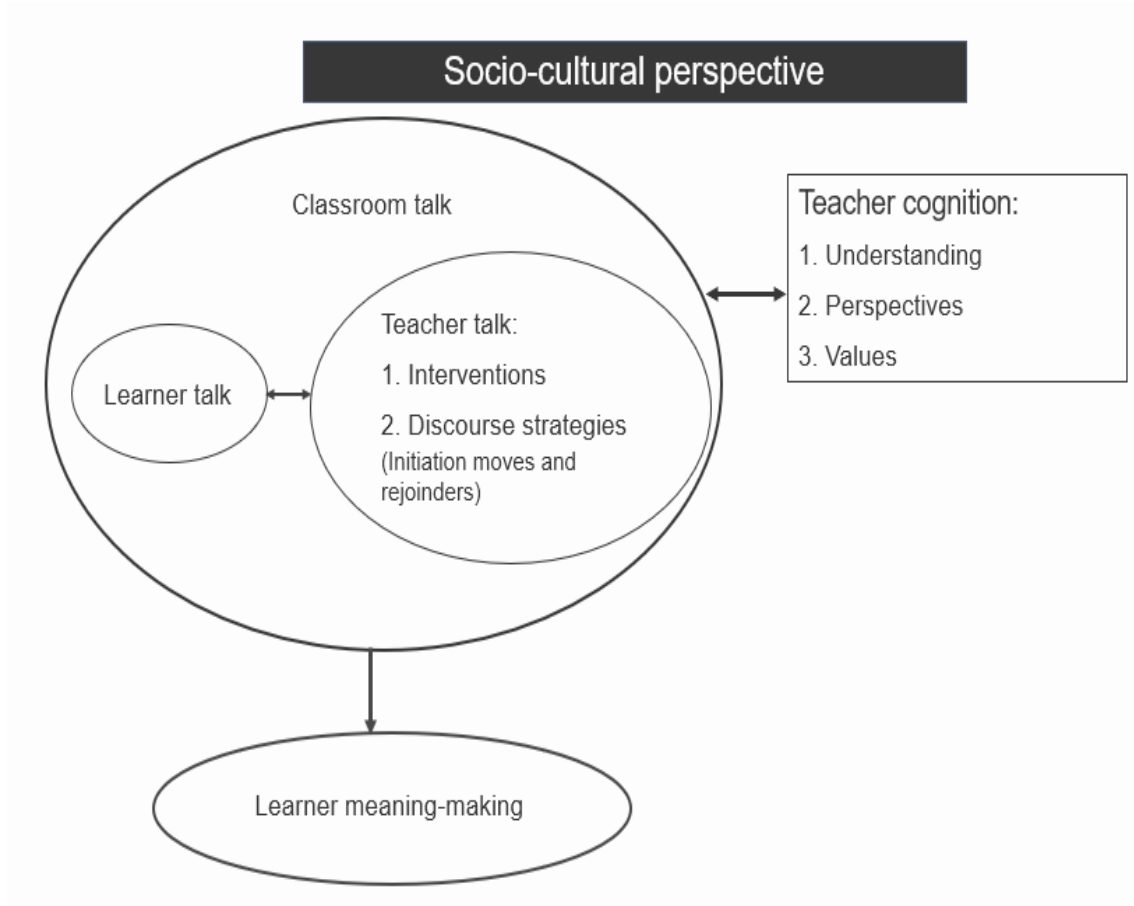


Figure 2.2 Conceptual framework for the study

2.9.1 Socio-cultural perspective

As shown in Figure 2.2 above, the central theory underpinning the present study is the socio-cultural theory that posits that learning takes place in a social context of the classroom using different forms of communication, including spoken language (Vygotsky, 1978). In other words, learning is socially mediated within the Zone of Proximal Development (ZPD) (Litowitz, 1993; Sarmiento-Campos et al., 2022), which is the gap in learners' cognitive development between them being able to problem-solve independently and requiring guidance to do so (Vygotsky, 1935). ZPD is the main tenet of the socio-cultural perspective that I am drawing from for the present study because of its role in leading to active learner thinking and not just memorisation (Margolis, 2020). The teacher helps

the learner navigate the ZPD through scaffolding, by bridging the gap between the learners' prior knowledge with the knowledge they need to learn.

Scaffolding, as defined by Bruner and Bruner (1990) involves the learner, under the tutelage of the teacher, mastering their own understanding, and using it as a tool for learning. The teacher passes their knowledge to the learner, gradually growing their knowledge of a specific subject matter (Sarmiento-Campos et al., 2022). This guides the learner in making meaning of the content being taught by, for example, incorporating new information with what they already know. In this way, prior knowledge acts as a foundation for the knowledge that the teacher will guide the learner through in the pursuit of meaning-making. The teacher uses talk as a verbal tool to scaffold the learners' knowledge and meaning-making.

An implication of this theory in science teaching and learning is that teachers need to provide learners with tools that scaffold the learning that takes place in a science classroom. The learner's learning takes place in two phases: socially, through the tutelage of the teacher, and then internally, when the learner internalises the new information (Puntambekar, 2022). In this study, I concur with Evnitskaya and Morton (2011) that talk is the main tool that can be used in science classrooms for scaffolding to afford learners opportunities for meaning-making. This is because, through talk, learners can exchange ideas and draw from each other's contributions to come to an understanding of the topic being discussed (Barnes & Todd, 2021). This is supported by Mortimer and Scott (2003), who proposed that knowledge is constructed through the interactions one has with others in the form of verbal communication, among other modes of communication. The teacher can support the learners' understanding of science

concepts by using talk moves in the classroom. This is the link between classroom talk and learner meaning-making, as shown in Figure 2.2 above.

In this study, as in that of Khoza and Msimanga (2021), I take the view that although learners are involved in classroom talk, it is the teacher talk that drives engagement. To facilitate this engagement, the teacher utilises intervention tools (Mortimer & Scott, 2003), which are initiation and rejoinder moves as described above (Correnti et al., 2015; Tytler & Aranda, 2015). Through using these moves, the teacher scaffolds the learning process and makes the content potentially meaningful for the learners.

2.9.2 Teacher cognition

The socio-cultural perspective is not only significant for how learners gain knowledge but extends to the teachers as well. This theory is important in demonstrating the influence of learning communities and experience on teachers' thinking, conceptualisations, and beliefs (Li, 2019). This highlights the socio-cultural interactions in teachers' lives that influence their cognition (Öztürk, 2021). The emergence of the study of teacher cognition and its effects on educational practices began four decades ago (Öztürk, 2021). Shavelson and Stern (1981) argued that studying teacher behaviour without considering teacher cognition is incomplete. To understand teachers' teaching practices, teacher cognition should be understood. Teacher cognition represents "the unobservable, cognitive dimensions of teachers – what the teacher knows, believes, and thinks." (Borg, 2003, p. 81). Borg (2013) further posits that teacher cognition is the central schema that has a vital role in the lives of teachers, comprising the cognitive constructs on the teachers' thoughts, knowledge and beliefs.

Teachers' beliefs have more influence on their decision-making, planning and behaviour towards learners than does their knowledge (Öztürk, 2021). These beliefs are about the learners themselves, the learning, the teaching, and the subject that the teacher teaches, as well as their role as the teacher (Calderhead, 1996). Along with their beliefs, Clark (1984) placed teachers' cognition in categories that include the teachers' theories and their interactive thoughts and decisions.

The decisions that are influenced by teachers' cognition include how they approach teaching and design their curriculum, and the methods that they use for assessment (Alzaanin, 2019). These can act as mediating forces for interaction between teachers' cognition, which, according to Vygotsky, guides and regulates behaviour (Manning & Payne, 1993), and their teaching practice. When looking at how teachers' cognition influences their feedback practice, Mori (2011) found that time constraints, school context, and the teachers' previous experience with learners and other teachers can shape their cognition. The teachers' experience and understanding in the classroom also contribute to teacher cognition (Borg, 2003; Feryok & Oranje, 2015). Even in the same context, teachers can display different teaching habits because of their cognitions of themselves as professionals (Öztürk, 2021), which shapes their cognition regarding justice and equity in the classroom (Sulistyowardani et al., 2020). The conceptualisation of equity, as part of a teacher's philosophy, can influence the learners (Chen & Abdullah, 2022).

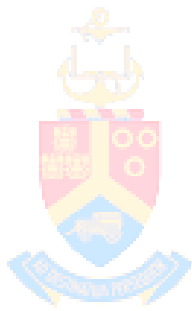
For all learners to achieve their learning outcomes, the teacher must create an inclusive and impartial learning context (Chen & Abdullah, 2022) by being

culturally conscious (Gay, 2018) and taking into account learners' different backgrounds to level the playing field for the learners, which speaks to the teacher's sense of justice and equity. By being aware of learners' socio-cultural diversity, teachers can incorporate their understanding, values and beliefs into their teaching (Lucas & Schecter, 1992), which will become inclusive, depending on the teacher's beliefs about equity. By having an equity-oriented cognition, teachers can positively affect the learners' social and intellectual engagement (Schreiner, 2014), because according to the socio-cultural theory, learning takes place in a social setting, where learners have the opportunity to engage with others. This makes the teacher's cognition crucial in the learners' process of learning. Just like learning, teaching takes place in the social context. In the social context of the classroom, the teacher drives classroom talk. The direction of the classroom talk is dependent on the teacher's cognition, such as how they initiate talk in the classroom, which will drive learner engagement and talk, eventually influencing the learners' meaning-making process.

2.10 Chapter Summary

This chapter reviewed the relevant literature about the current study. I have highlighted the various aspects of meaning-making, and how these influence and are influenced by classroom talk, which involves learners engaging with ideas to incorporate them into their existing knowledge. I have further highlighted the challenges and aspects of teaching and learning population ecology, as well as how the topic is neglected in research. The last section of this chapter illustrated the relationships between the socio-cultural perspective and the influence of teachers' cognition on how they conduct classroom talk.

The next chapter will detail the methodology of my study, which includes the steps I took before, during, and after data collection and analysis.



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CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

In this chapter, I detail the steps I took to conduct this study. I start by detailing the chosen research paradigm for the present study. In the second section, I discuss the research paradigm I used, which informed the methodological approach and is discussed in the third section. In the fourth section, I discuss the research strategy that best suited my study. In the fifth section, I go into detail about my research process, which entails my sampling. This includes profiling of the teachers, the procedure I followed to collect the data, including audio-recordings of the lessons and interviews, and how I analysed both data sets. In section six, I discuss how I ensured the research rigour of the present, including its credibility, dependability, and transferability. Lastly, I detail the steps I took to make my study ethical.

3.2 Research paradigm

The term 'paradigm' is Greek in origin (Kivunja & Kuyini, 2017), and is used in English to mean pattern or example (Merriam-Webster Dictionary, 2002). In terms of research, Fraser (2004) defines a paradigm as "a set of beliefs about the way in which particular problems exist and a set of agreements on how such problems can be investigated" (p. 59). This definition supports that of Guba (1990), who further says that paradigms guide action. This is because each paradigm offers a specific way of seeing and understanding the world (Mukherji & Albon, 2022). How a paradigm is understood shapes the investigations that a researcher undertakes (Kamal, 2019) to discover knowledge.

For this study, the most appropriate paradigm was the interpretivist paradigm because the paradigm acknowledges that meaning is subjective and is dependent on each person's experience. The interpretivist paradigm states that knowledge and truth are subjective and that multiple realities have different interpretations (Ikram & Kenayathulla, 2022; Pervin & Mokhtar, 2022). Because I was seeking to only observe the different teachers in their natural settings, a pragmatic paradigm was not suited for this study, as it situates the researcher as an agent of change in the study (Goldkuhl, 2012). Positivism was also eliminated due to its stipulation that the results of the study be generalisable (Ikram & Kenayathulla, 2022; Junjie & Yingxin, 2022), which is in opposition to my goal of understanding the different realities of the teachers without generalising their experiences due to their different perspectives and contexts.

Merriam and Tisdell (2015) argue that the purpose of interpretivism is to describe, interpret, and understand different realities that have their own unique contexts. People are different and their realities are just as different. This study investigated the different realities of participant teachers as they use talk as an aspect of language to deliver content. Because meaning-making is a personal and subjective matter, it is always open to interpretation. This is why I found this paradigm to be the most appropriate for this study: it allowed me to understand the different realities of the teachers in depth (Alharahsheh & Pius, 2020; Junjie & Yingxin, 2022; Pervin & Mokhtar, 2022).

3.3 Methodological approach

My chosen research paradigm, interpretivism, informed the methodological approach that was best suited for the present study. I used a qualitative approach. Van Maanen (1979) defines qualitative research as “an umbrella term covering an array of interpretive techniques which seek to describe, decode, translate, and otherwise come to terms with the meaning, not the frequency of certain more or less naturally occurring phenomena in the social world” (p. 520).

Qualitative research encompasses a naturalistic and interpretive approach to studying the world (Denzin & Lincoln, 2011), and seeks to attain a deep understanding of a specific case (Alharahsheh & Pius, 2020; Cohen et al., 2017) due to the assumption that multiple realities are constructed socially and the knower and known are inseparable from each other (Yilmaz, 2013). This demands that the method of inquiry be subjective. The qualitative approach focuses on contextualisation, interpretation of different realities, and understanding the perspectives shaped by those different realities. It does not use numerical indices and manipulated variables as is the case for the quantitative method, instead, it describes the context to understand the patterns seen in a natural environment (Yilmaz, 2013).

For this study, I sought to have an in-depth understanding of the different realities of Grade 11 Life Sciences teachers as they used talk moves while teaching population ecology. I found that qualitative research was the best fit to understand the teachers' realities. This is because, unlike a quantitative study, its goal is not to make generalisations, but to obtain insight using different methods, drawing

from different meanings and experiences (Cohen et al., 2017). Another reason for choosing qualitative inquiry over quantitative was that quantitative research implies that there is only a single, objective reality, and this cannot be the case with different teachers in different contexts.

3.4 Research design

The research strategy of this study was guided by my research questions. Ragin and Amoroso (2011) propose that a research design is the process of collecting and analysing the findings to answer the research questions.

A design I considered for my study was the case study design. Yin (2009) posits that a case study “investigates a contemporary phenomenon in its real-world context,” (p. 31). I found the case study design to be the best design aligned with my study.

Multiple factors of this design solidified my choice for it. A case study provides an interpretation that encompasses the social context (Mfinanga et al., 2019; Suryani, 2008), and offers more detail about the phenomena under study (Suryani, 2008). A case study can be used to describe, explain, and illustrate the unique situations of people (Cohen et al., 2017) in their natural environment (Yin, 2009). This is because it focuses on the context of the situation, the variables at play, and how they unfold. All these factors led to choosing case study design for this study.

The goal of this study was to gain an in-depth understanding of talk moves that teachers use when teaching population ecology, and how these facilitate

meaning-making for the learners. Case studies allow for such deep understanding (Creswell & Poth, 2016). For this study, the participating Grade 11 Life Sciences teachers and the lessons they gave while teaching population ecology were each taken as separate cases. This made my study a multiple case study, allowing me to fully understand each teacher's context. The reasoning behind the choice of making each teacher a separate case was that it allowed me to analyse each teacher concerning their own context instead of analysing them as a collective, making the findings more robust (Yin, 2009).

3.5 Research process

The quality of a research study relies on multiple factors, including the sampling (Cohen et al., 2017). In this section, I discuss how I selected my participants and the reasons therefor, after which I profile them. I also discuss the data collection procedure for both the lesson audio recordings and interviews. Lastly, I go into detail about the analysis of the data and the justification for those choices.

3.5.1 Selection of participants

For this study, I used both purposive and convenience sampling. As I did not seek to study Life Sciences teachers in all grades, but was specifically interested in Grade 11 Life Sciences teachers while they taught population ecology, I used purposive sampling as it dictates that I deliberately choose my sample (Cohen et al., 2017). The selection criteria of the participants were that they must be Life Sciences teachers teaching Grade 11 in the year in which the data was collected. The reason behind my choice for convenience sampling is that it involves choosing participants that are most accessible to me (Cohen et al., 2017).

Convenience sampling has the added benefits of being more cost-effective and less time-consuming (Golzar et al., 2022). The study was restricted to Gauteng Province high schools in the Tshwane West district, due to their proximity. Although the use of these sampling methods reduced my sample pool, it allowed for a more in-depth understanding of the different teachers' natural environment in the classroom.

For this study, I sought experienced teachers as participants. Although there is no universal consensus definition of what constitutes an experienced teacher, I adopted the categorisation by Graham et al. (2016) of experienced teachers as having five or more years in the profession. This five-year experience includes that of teaching Life Sciences. This categorisation does not imply the informed teacher's understanding of talk, nor quality teaching regarding talk. The reason for choosing experienced teachers was to gain an understanding of how teachers teach the topic of population ecology in their classrooms. A further reason for this choice was that teachers would be familiar with the topic.

The table below shows the different teacher profiles, with the chosen pseudonyms of each teacher, and their education, context, and experience.

Table 3.1 Teacher profiles

Pseudonym	Mandy	Ntando	Tebogo
Qualification	Masters in Science in Agriculture, and Postgraduate Certificate in Education (PGCE)	Bachelor of Science in Zoology & Psychology, and PGCE	Bachelor of Science in Microbiology & Genetics, and PGCE
Age group	31-40	51 and above	21-30
Teaching experience	7	27	5
Years teaching Life Sciences	7	24	5

Other subjects that the teachers are teaching	Natural Sciences	Natural Sciences and Physical Sciences	Life Orientation
School type	Township school	City school	Rural school

I chose a pseudonym for each teacher using common South African names. These names were Mandy, Ntando, and Tebogo. The teachers all have different dynamics and contexts. Their teaching experience in Life Sciences ranges from five to 27 years, making Tebogo a newly experienced teacher. The teaching experience of the teachers showed that Ntando was a veteran teacher and Mandy and Tebogo were recently novice teachers, as was reflected by their age groups and number of years teaching. Notably, none of the three teachers has a Bachelor of Education qualification, but all have degrees in Science, Technology, Engineering and Mathematics, and PGCE qualifications.

As posited by Howie (2005) the context and setting of a school play a pivotal role in how teaching and learning take place. All three teachers were teaching at state schools, which used the CAPS curriculum for Life Sciences, as with all other subjects. Ntando taught in a fee-paying school, which is often the case in city schools. Both Mandy and Tebogo did not teach at fee-paying schools, with Mandy teaching in a township school and Tebogo teaching in a rural school.

Rural schools are notoriously under-resourced and have poor infrastructure (Du Plessis & Mestry, 2019; Lombo & Subban, 2024; Mokgwathi et al., 2023), and this created a different perspective in the case of Tebogo. Not only are rural schools lacking in infrastructure, but in human resources as well, struggling to obtain and retain teachers, as shown in the study by Masinire (2015). This teacher

shortage may explain the unlikely combination of subjects taught by Tebogo. Township schools are not much better off (Mashaba & Maile, 2013; Ramnarain, 2014), but the shortage of teachers is not as dire as in rural schools (Mphatsoe & Motseke, 2014). Both Mandy and Tebogo's schools are quintile 1 schools, meaning they do not pay school fees, and are highly subsidised by the state. City schools are advantaged due to their proximity to the city and facilities (Mestry, 2018). Ntando's particular school is a quintile 5, fee-paying school, and therefore, can afford more teachers, which allows for smaller classes (Garlick, 2013). Although they receive the lowest state subsidy due to their status as quintile 5 (Dass & Rinqest, 2017), city schools are usually the best-resourced schools (Ramnarain, 2014). The different contexts of the teachers solidified my choice of using a multiple case study for the present study.

3.5.2 Data collection procedures

Two data collection methods were used to gain rich data on teacher talk. The methods were classroom observations and SRIs. These data sources are described in detail below.

3.5.2.1 Classroom observations: Lesson audio data and field notes

The first data collection method was audio-recording the lessons and taking field notes. The disadvantage of the audio recording was that it left out non-verbal communication, but this was supplemented by field notes. This omission did not affect the study because its focus was verbal talk. Audio recordings of the teachers' lessons were taken while they were teaching population ecology. Table 3.2 below presents details of the lessons that the teachers gave, and their duration.

Table 3.2 Lessons given and their duration

Teacher	Lesson and focus	Lesson duration	Total duration of lessons
Mandy	1. Introduction and definitions	27 minutes	93 minutes
	2. Population size and density	44 minutes	
	3. Population growth, summary	22 minutes	
Ntando	1. Introduction and definitions	21 minutes	67 minutes
	2. Interactions in the environment	22 minutes	
	3. Population growth curves, summary	24 minutes	
Tebogo	1. Introduction and definitions	29 minutes	73 minutes
	2. Human population, interactions in the environment	20 minutes	
	3. Population growth curves, summary	24 minutes	

All three teachers presented three lessons each. The duration of their lessons ranged from 20 to 44 minutes. Each lesson duration was calculated from the time the teacher started teaching the content to the time they stopped and dismissed the class or gave learners an activity. The audio-recorders were placed in the middle of the classroom to capture both the teacher and learners' utterances during the lessons.

3.5.2.2 Stimulated recall interviews

To understand the teachers' talk practices and what could have influenced how they enact talk when teaching, I used stimulated recall interviews (SRIs) to get an understanding of the reasoning behind the teachers' utterances in class. These interviews are described by Riazi (2016) as interviews that are used to help participants elaborate on the decisions and actions they have taken. These interviews were conducted after the preliminary analysis of the lesson audio data. I identified areas of interest from the transcripts (across the lessons). These areas of interest include when the teacher referenced prior knowledge or experience of the learners, the tone that the teacher used when using talk moves, and the opportunities given to learners to participate, or the lack thereof. I then generated

interview questions regarding the actions taken by the teacher. Each teacher had interviews that were based on all their lessons. This means that the interview questions were different for each teacher.

Table 3.3 below shows examples of questions posed to the teachers after they had given their lessons.

Table 3.3 Examples of questions asked during interviews

Teacher	Examples of questions asked	Duration of the interviews
Mandy	I noticed that you were having learners repeat the definitions and some of the concepts that you were teaching while you were teaching it. Can you elaborate as to why you were doing that?	31
Ntando	That's just an example of how you were challenging the answers. So why? What is the reason for doing that?	28
Tebogo	What is the purpose of making obviously false or misleading statements?	35

Because each teacher taught differently and used different talk moves during their lessons, I asked them specific questions regarding the lessons that they gave to gain insight into their reasoning for using the talk moves that they did (see Table 3.3). In Mandy's lesson, there were instances of repetition from the learners, which is why I asked that question. Ntando challenged the learners with his questions, while Tebogo sometimes made false statements. These moves were not unique to just one teacher, and some were shared. Therefore, during the interview, I would refer the teacher to specific instances as revealed in the audio-data transcript. At times, I would play the audio as a reminder of what they had said in their lessons. These interviews were audio-recorded and transcribed verbatim for analysis.

3.5.3 Data analysis

The data collected from the lessons were analysed using two different frameworks, one framework for the teacher utterances, the other on learner contributions. Below, I briefly discuss how the data sets were analysed. In Chapter 4, I provide a detailed description of the analysis.

3.5.3.1 Analysis of transcripts from audio data

To analyse the data, the ATM framework by Correnti et al. (2015) was used. This framework highlights and emphasises the role of the teachers' talk moves during classroom interaction (Correnti et al., 2015). For this study, the talk moves were coded as either initiating moves or rejoinders on the first of three levels.

Initiating moves include: a) the launch, in which teachers ask open-ended questions at the start of the lesson; b) the literal, asking a question that requires the learners to answer with facts that have been taught; and c) providing information, where the teacher gives the learners relevant information that has already been taught, has been written on the board, or is in the prescribed text such as the textbook. Rejoinder moves include: a) the repeat, which is when the teacher reiterates what the learner has said; b) the uptake, when the teacher uses the point that the learner has made to further the discussion; and c) the connection, which is used to get the learners to make a connection between what has been discussed with the content that has been delivered, or the information in the text.

I found that the ATM framework was not descriptive enough, and supplemented the analysis of the talk moves with the Teacher Discursive Moves (TDM)

framework by Tytler and Aranda (2015). This allowed me to succinctly analyse the teachers' utterances, as shown later in Chapter 4. The incorporation of the TDM framework into the ATM framework is presented in Table 3.4 below. This led to coding on three levels.

Table 3.4 Description of talk moves by the ATM and TDM frameworks

Nature of talk moves (Level 1 coding)	Category of Talk move (Level 2 coding)	Description of categories	Sub-category of talk moves (Level 3 coding)	Description of sub-categories
Initiations	Launch	Open-ended question at the beginning of a segment in a lesson	N/A	N/A
	Literal	Question asked for the retrieval of factual information		
	Providing information	Teacher gives information related to the instructional talk at hand		
Rejoinders	Repeat	Teacher echoes learner response	Restating	Repeating the question
			Marking	Teacher marks the learner's input
			Affirming	Teacher offers positive response to learner input
	Uptake	Teacher uses learner response to extend, deepen, and clarify the discussion	Reframing	Asking the question in a different way
			Requesting confirmation	Asking learners to confirm the intended meaning
	Connection	The teacher tries to get the learners to make an explicit connection	Elaborating	Asking learners to elaborate their input further
Revoicing			Re-casting language to introduce scientific language	

	Extending	Asking related questions to introduce a new element	Challenge directly	Challenges learners to reconsider their response
			Challenge to extend ideas	Challenges learners to use their ideas in a new context

To analyse the learner talk moves, I used the AST framework by Hardman (2019). This framework conceptualises the talk moves of the learners in response to the teachers' talk moves or amongst themselves. This allowed me to investigate the learners' utterances when engaging in the lesson because the ATM framework mainly focuses on the teacher and not the learner. Table 3.5 below presents the AST framework as described by (Hardman, 2019).

Table 3.5 AST Framework

Code	Student talk moves	Description
CSQ	Closed student question	Learner asks a closed question
OSQ	Open student question	Learner asks an open question that requires some elaboration
BSC	Brief student contribution	The learner gives a brief, often single-worded contribution
ESC	Extended student contribution	The learner gives an elaborative answer

As seen in Table 3.5, student talk can be in the form of a question directed at the teacher, as a closed or open question, or a contribution such as answering questions from the teacher. The nature of these student talk moves is discussed in more detail in Chapter 4.

3.5.3.2 Analysis of SRIs

For the interview section, I used narrative analysis and the analysis of narratives approaches. Narrative analysis is defined by (Labov, 1972) as "a family of methods for interpreting texts that have in common a storied form," (pp. 359–360). This analysis method allowed me to unpack the analysis as a story that was

chronological instead of thematic, complementing the multiple case study nature of this research and allowing me to analyse each case separately, as its own narrative.

In this analysis, I used the different elements that emerged from the data and incorporated them into a story according to the themes presented. Analysis of narratives is based on the narrative that is found within the data (Adesope & Nesbit, 2013). This allowed me to analyse the teacher talk moves that are used in a thematic form to identify and compare the patterns I found in the data, during which time I looked for 'eureka' moments in the data. Due to the nature of a case study, each case has its own narrative, which was why I additionally chose to use analysis of narratives as a method: to highlight the similarities and differences of the usage of talk moves used by the different teachers (Josselson & Hammack, 2021; Smith, 2016). In Chapter 4, Section 4.3, I explain in detail how the SRIs were analysed.

3.6. Research rigour

Credibility is the ability to inspire belief (Merriam-Webster Dictionary, 2002). Credibility speaks to the procedures in the method of the study if the analysis is based on a set standard (Polit & Beck, 2010). Lincoln and Guba (1985) go further to say that trustworthiness cannot be established without credibility. To enhance credibility, the case studies used observations and interview to collect data in the form of audio recordings, which I shared with the participants, along with the transcripts of said recordings as a method of member checking, thereby enhancing the trustworthiness of my study (Birt et al., 2016). I used the ATM

framework since this is an established research method, and using such methods increases the credibility of the study (Shenton, 2004). I triangulated the study by collecting data using two tools: audio recordings and interviews, which helped in compensating for their limitations (Guba, 1981). Lincoln and Guba (1985) argue that demonstrating credibility goes a long way to ensuring dependability.

Dependability is concerned with the stability of the data (Polit & Beck, 2010). This included taking note of all activities carried out for the data collection. The data collected was shared with my supervisor. I also used iterative questioning during the interviews to ensure that the teachers' responses were answering the question and that they did not misunderstand or misinterpret the questions. Furthermore, I detailed all the actions taken during the data collection process. During the analysis of the data, I invited my supervisor to collaborate in the coding of the interviews. This helped strengthen the quality of the study, as I am a novice researcher. The transferability of the study concerns the usefulness and relevance of the findings compared to similar contexts. The reader determines how the study fits into their own situation (Connelly, 2016).

3.7 Ethical considerations

The first step I took to ensure ethical compliance was to apply for ethics clearance from the Faculty of Education of the University of Pretoria's Ethics Committee (Appendix A), and then sought permission from the Department of Basic Education to carry out the study (see Appendix B). The next step was to obtain informed consent from school principals to conduct the study in the various schools (Appendix C), followed by gaining consent from the teacher (Appendix

D) and learner participants (Appendix E) of the study, and the learners' guardians (Appendix F). To ensure informed consent, I fully explained the study to participants so that they could choose whether to participate in the study.

The South African Constitution stresses the importance of the right to privacy (Constitution of the Republic of South Africa, 1997), and the Protection of Personal Information Act has been put in place to ensure this right is protected (De Bruyn, 2014). To ensure the privacy of the participants, I gave them consent forms that detailed what was expected and how their privacy would be respected for the study. The considerations for the rights of the participants were further taken, such as ensuring the participants' anonymity by not disclosing any information that could be used to identify them, such as the name of the school, race, gender, age, and other identifiable information of the teachers. Finally, all recordings and transcripts were made available to the participants to maintain trust between the participant and the researcher (Cohen et al., 2017).

3.8 Chapter Summary

In this chapter, I detailed the steps I took for my study, including my chosen paradigm, research design and methodology. I used an interpretivist, qualitative case study for my study. I gathered the data using interviews and audio recordings of the lessons from the teachers, and analysed the data using multiple frameworks. I detailed the ethical and quality criteria that I used to guide my study. In the next chapter, I discuss the findings of the data collected using the frameworks mentioned in this chapter.

CHAPTER 4: DATA ANALYSIS AND FINDINGS

4.1 Introduction

In this chapter, I present the data and findings of the current study on teacher talk moves, how they use these talk moves to facilitate meaning-making, and factors that influence the teachers' use of talk moves to facilitate meaning-making. I start by presenting a detailed description of the analysis of the two data sets: transcripts from audio-recorded lessons and stimulated recall interview transcripts, and then present the findings.

4.2 Detailed description of the analysis of audio-transcripts of lessons

To analyse the transcripts from teaching, I employed deductive analysis as stipulated in Chapter 3, Section 3.5.3.1 The deductive analysis was informed by the Analysing Talk Moves (ATM) framework of Correnti et al. (2015) (see Table 3.4), which separates the nature of the talk moves into categories. I supplemented this framework to add sub-categories using the Teacher Discourse Moves (TDM) framework of Tytler and Aranda (2015) (see Table 3.4). The steps that I followed in the analysis are described below.

Step 1: Familiarising myself with the data. I read through all the transcripts while listening to the audio transcripts and reading the field notes (see Appendix G). The goal here was to understand what was contained in the transcripts and the field notes.

Step 2: Dividing the transcripts into episodes. I started by dividing each teaching transcript into episodes. These episodes became my definition of a unit

of analysis. Episodes are described as teaching events where an idea characterised by one or more concepts is taught to completion (Khoza & Makgata, 2024). This is because meaning-making is linked to the ideas that are taught in specific phases of the lesson. In dividing the episodes, I also relied on the teacher's cues. For example, when the teacher said, "Okay...now we are looking at..." or "Let's move to...", this signalled the start of a new episode. However, this was only considered if the concept of discussion was different from the previous one. Table 4.1 below shows the episodes that were identified from the lessons per teacher, and the number of episodes in each lesson.

Table 4.1 Lessons and number of episodes

Teacher	Lessons	Number of Episodes
Mandy	1. Introduction and terminology	8
	2. Population size and density	6
	3. Population growth, summary	5
Ntando	1. Introduction and terminology	6
	2. Interactions in the environment	5
	3. Population growth curves, summary	8
Tebogo	1. Introduction and terminology	5
	2. Human population and interactions in the environment	8
	3. Population growth curves, summary	6

As can be seen in Table 4.1, there are different numbers of episodes per lesson. This is because the teachers would spend more time on teaching a single idea and spend less time on teaching another idea.

Step 3: Coding the teachers' utterances. I started by coding the teachers' utterances at three levels, using the established framework. At level 1, I determined if the discursive move was an initiation or a rejoinder as per the Initiation-Response-Evaluation/Feedback (IRE/F) triad. At level 2, I then

interrogated the category of the initiations and the rejoinders. The initiations were categorised as launch, literal or providing information. The rejoinders were classified according to the four categories shown in Table 3.4 (see Chapter 3). Third-level coding involved only coding for the rejoinders into specific rejoinders that teachers used as per Tytler and Aranda's (2015) sub-categories of discursive moves. These rejoinders are also depicted in Table 3.4. For example, if the category was a repeat, I illustrated the nature of this repeat (whether it was affirming or restating).

Step 4: Coding learner utterances. In this step, I coded the learner utterances at three levels. Level 1 involved simply determining if the contribution is from a learner (coded "learner response" as per the IRE/F interaction pattern). Level 2 involved deductively using the framework by Hardman (2019) for AST (see Table 3.5 in Chapter 3). For example, a short contribution where a learner says "No" would be coded "student brief contribution". Coding at the third level involved interrogation of the learners' contributions in line with the indicators of learners making meaning. These indicators are presented in Chapter 2, Section 2.4. For example, I would code a learner's brief contribution as "affirming the previous learner" if their contribution builds on the previous learner's response. Therefore, coding at this level was both inductive and deductive. Table 4.2 below shows the coding process followed. During the coding process, I invited my supervisor to do the same and compared the codes to use the most fitting. We discussed the coding process and concluded regarding the coding of utterances.

Table 4.2: An example of coding lesson transcripts

Speaker	Utterance	Level 1 code	Level 2 code	Level 3 code
Teacher	So what is a factor that affects population size when the population is not large? We said disease and predation affect the population size...	Initiation	Literal	N/A
Learner 1	Shortage of food	Learner response	Brief student contribution	Response to teacher question
Teacher	No.	Rejoinder	Acknowledging	
Learner 2	Predation?	Learner response	Brief student contribution	Uncertain learner response
Learner 3	Competition?	Learner response	Brief student contribution	Uncertain learner response
Teacher	Natural disaster. Like a tornado or an earthquake.	Rejoinder	Elicitation	
Learner 3	The storm yesterday.	Learner response	Extended student contribution	Links to real life
Teacher	Yes, like the storm yesterday.	Rejoinder	Repeat	Affirming
	They will affect the population size whether it's large or small.		Connection	revoicing
	So those factors that affect the population when it's large, when it's small (explanation continued)		Providing information	N/A
Learners	Yes.	Learner response	Brief student contribution	Agreeing
Teacher	Are you sure?	Rejoinder	Uptake	Requesting information
Learner 1	You mean like the storm yesterday?	Learner response	Brief student question	Linking with real life
Teacher	Yes.	Rejoinder	Acknowledging	

As can be seen in Table 4.2, the teachers' and learners' utterances were coded at three levels. It is important to note that in one turn, the teacher's utterance would be coded several times. For example, the teacher would start by

acknowledging a learner's response and then use another move in the same line or turn.

4.3 Detailed analysis of the stimulated recall interviews

As I have indicated in Chapter 3, Section 3.5.3.2, in analysing the SRIs, I followed both the narrative analysis and analysis of narratives. Narrative analysis allowed me to re-tell the story of the Life Sciences teachers, while analysis of narratives allowed me to generate codes and themes from the data. Therefore, in presenting the findings, I used a narrative approach to unpack the teachers' utterances that characterised the findings to assist me in addressing the research question regarding factors that influence the teachers' use of talk moves. Below, I present the steps that I followed in analysing the interviews.

Step 1 – Reading the transcripts: I started with reading transcripts several times. While reading the transcript, I also listened to the audio to fully familiarise myself with what is contained in the interviews.

Step 2 – Coding the first interview transcripts: I started with the transcript from one teacher (Ntando) and coded them inductively and deductively. The deductive coding was informed by the literature review and theoretical perspectives presented in Chapter 2, Section 2.9. Table 4.3 below shows an example of the codes that were used.

Table 4.3: An example of coding the interview transcripts

Utterance	Code assigned
By asking questions that, uhm, <u>link their relevant previous knowledge</u> ² to what you <u>want them to understand</u> ⁶ . Uhm, and also yeah, <u>ask them questions, they ask you questions</u> ³ . Mainly that and <u>explanations in terms of case studies</u> ⁷ or uhm, <u>give them something to role play</u> ⁸ .	² link knowledge ⁶ understand ³ questions and answers ⁷ case study ⁸ role play
My understanding of that is that <u>you need to have a proper, good relationship with the learners</u> ⁹ in order to make <u>them feel comfortable so that they can actually ask questions</u> ¹⁰ without feeling threatened or intimidated by me. So to get them into an <u>environment which is friendly but firm</u> ¹¹ so that they can actually feel that <u>they are able to tell me when they don't understand something or if they are unsure</u> ¹² about something that they won't feel threatened in order so that in order for me to be able to get them to <u>understand what I'm trying to teach them</u> ⁶ .	⁹ good relationship ¹⁰ comfortable to ask questions ¹¹ comfortable environment ¹² express uncertainty ⁶ understand
The most important thing is that they need to <u>understand the concepts that are being taught</u> ¹³ , so to <u>ask them leading questions</u> ¹⁴ which will <u>link what they know to what I'm trying to teach them</u> ² . And then also to help them to <u>feel that they are able to ask questions</u> ¹⁰ when they need to and, yeah.	¹³ understand concepts ¹⁴ leading questions ² link knowledge ¹⁰ comfortable environment

As can be seen in Table 4.3, several codes were used in the analysis of the interview transcripts.

Step 3 – Inviting my supervisor to code the same transcripts: I then invited my supervisor to code the two transcripts. We met and discussed the codes and concluded regarding the coding process. This process allowed us to compare our coding and rephrase some of the codes we had assigned to the teacher utterances.

Step 4 – Extracting the codes: I then extracted the codes from the first transcript and described them. The goal here was for me to understand their meaning before applying them to the second set of transcripts.

Step 5 – Coding the rest of the transcripts: I then coded the rest of the transcripts by first applying the extracted codes. In the process, some codes were rephrased while others emerged from the transcripts. Please see Table 4.2 for some of codes that were used in the interview transcripts and their descriptions.

Step 6 – Collapsing the codes into categories: After coding the rest of the transcripts, the codes were then merged into categories. Although the codes were collapsed into categories, I used the teachers' utterances in specific places to describe the factors that influenced the use of talk moves in presenting the findings.

4.4 Presentation of findings

Owing to the research strategy used in this study, findings are presented per case. In each case, I present how the teacher used talk moves to facilitate meaning-making by using excerpts from specific episodes or a combination of episodes. However, in the process, I also present narrative evidence of some of the factors that influenced the use of certain talk moves (or lack thereof).

4.4.1 Case 1: Mandy

As stated in Chapter 3, Mandy is teaching in a quintile 1 township school, which is defined by (Department of Basic Education, 2004) as “the group of schools in each province catering for the poorest 20% of learners” (p. 8). Mandy was observed three times while teaching population ecology. Starting with the moves that Mandy used, Table 4.4 below illustrates the prevalence of the talk moves that were used.

Table 4.4: Prevalence of talk moves in Mandy's lessons

Nature of talk moves	Category of Talk move	Descriptions of move	Lesson 1: Introduction, definitions	Lesson 2: Population size, density	Lesson 3: Population growth curve, population size estimation, recap	Total
Initiations	Launch	Not applicable	5	10	4	19
	Literal		9	15	10	34
	Providing information		4	11	4	19
Total initiations per lesson			18	36	18	72
Rejoinder	Repeat	Restating	2	2	0	4
		Marking	1	1	1	1
		Affirming	2	1	0	3
	Uptake	Reframing	2	2	0	4
		Requesting information	2	3	0	5
	Connection	Elaborating	1	1	0	2
		Revoicing	4	2	0	6
	Extending	Challenge directly	3	0	0	3
		Challenge to extend ideas	3	4	0	7
Total rejoinders per lesson			20	16	1	37

The above Table 4.4 displays the talk moves that Mandy used and their prevalence in her lessons. Although Mandy initiated discussions many times, as seen in lesson 2, it does not mean that all the initiations led to interaction episodes where rejoinders would be used. In some cases, the initiations were questions followed by the provision of information in a non-interactive manner (see lesson 3 as an example). Mandy's most prevalent initiation move was the literal moves characterised as close-ended questions. The frequency of these moves ranged from 9 to 15 in the different lessons and totalled 34.

In terms of the rejoinders, the rejoinder that she used the most was the extending move to challenge learners to extend their ideas (Gümüşok & Balıkçı, 2020; Li & Zhang, 2022), although none were used in her final lesson. The final lesson had the lowest number of talk moves overall, amounting to 19, and only one of those was a rejoinder, with the remaining 18 moves being initiation moves. This shows that in some cases, Mandy did not follow up on the learners' contributions in the last lesson.

Mandy used various talk moves to facilitate meaning-making when teaching the topic of population ecology, especially in the first and second lessons. Below, I present some of the excerpts from Mandy's lessons to not only show how meaning-making was facilitated but also some of the opportunities missed. I also use data from semi-structured interviews to narrate some of the factors that influence the use of talk moves to facilitate meaning-making.

Excerpt 1

Turn	Speaker	Utterance
1	Mandy:	Okay, so a population is. Let me write it down for you. Let me say it, and then I'll write it down so that you can remember it again, yes?
2	Learners:	Yes.
3	Mandy:	A population is a group of the same species living in the same area...
4	Learners:	At the same time
5	Mandy:	So, in the picture here, we see that...

Excerpt 1 above comes from Mandy's first lesson, in which she was teaching terminology. In turn 1, signifying the start of the second episode of the lesson, Mandy used the board to write out the first part of a definition of the term population for the learners. After writing the definition, she began to define it out

loud and had the learners complete the rest of the definition from the board in unison, in this way, Mandy got the learners to join in the lesson, because they were not blindly repeating what Mandy was saying. Instead, they were engaging with the text written on the board. Mandy then used this as an opportunity to break down what was written on the board in turn 5. She had the learners repeat the three characteristics of a population. As she wrote the definition on the board, she also displayed various pictures of what populations look like in her PowerPoint presentation. Not only did this give the learners a picture of what a population looks like, but also what it does not look like. This provided learners with an opportunity to visualise what populations look like, thus, differentiating the terms population and community.

Although the provision of a picture and writing down the definition on the board may have allowed meaning-making to some extent, one can argue that this approach has limitations, as learners would know just the basic definition of population ecology. However, an opportunity for meaning-making was also evident when she made links to the content that learners will encounter in the upcoming grades. During the lesson, she said:

Guys, remember this, these definitions, you will find these definitions also next year when we are going to do what we call evolution. You are going to have to know these definitions next year as well. You will be in Grade twelve.

Making this link between the current knowledge and the future knowledge that learners will learn, she gave them an incentive to know and understand the concepts. In this regard, Mandy showed that she was already preparing the learners for the next grade, and laying a foundation for the upcoming grade. This

supported what she said in the interview, that learners have a foundation that they build on when they are learning. By stressing the importance of the concepts and building the learners' knowledge for the next grade, Mandy also reduced her workload for when she teaches evolution in Grade 12.

In summary, instead of asking a specific question in the first turn, Mandy provided information (as well as being proactive on the prior knowledge that learners will need for the upcoming grade). Repeating initiation moves coupled with the provision of information allowed learners to make meaning of the concepts. However, what limited this process to some extent was getting learners to understand the basic definitions of terminology.

The second excerpt comprises episode 3 of Mandy's lesson. In this particular excerpt, Mandy has just finished defining what population means. She was moving on from that to presenting examples.

Excerpt 2

Turn	Speaker	Utterance
1	Mandy:	So now let's just make an example. Let's just make an example about this word population. The word population. Is this class and the next class the same population?
2	Learners:	No.
3	Mandy:	Why not?
4	Learner 1:	This class is not like the other class.
5	Mandy:	No. I'm saying, is <i>this</i> class and the <i>next</i> class the same population?
6	Learners:	Yes.
7	Mandy:	Who says yes? Okay. He says yes. Let me answer. Answer.
8	Learner 1:	Because we are the same species. Same species.
9	Mandy:	He says, yes, because we are the same species.
10	Learners:	Learners start arguing

- 11 **Mandy:** He says, we are the same population because we are the same species. So who says yes, we are the same population. This class and the next class. Okay, so when? Why are you saying that? Yes.
- 12 **Learner 2:** We are at the same environment at the same time.
- 13 **Mandy:** So are you at the same environment with the person next door at this time?
- 14 **Learners:** No.
- 15 **Learner 3:** Yes, teacher.
- 16 **Mandy:** At the same time?
- 17 **Learner 3:** No, teacher.
- 18 **Mandy:** Can you see that you are not in the same environment as the person next door in this time? So you cannot be the same population.

In turn 1, Mandy introduced an example concerning the definition of population. As shown in the excerpt, Mandy's talk move was an initiation move in the form of a closed question. The purpose of this question was for the learners to situate themselves in the definition. When Mandy asked the question in turn 1, the learners gave a brief student contribution by disagreeing. When a learner gave an elaboration in turn 4, Mandy might have prevented him from making meaning of the concept by evaluating negatively without unpacking the inherent message in the learner's response. However, an opportunity was provided again by asking the question again in turn 5, while stressing the words 'this' and 'next' to give the learners a clue that the two classes have a spatial difference. In turn 8, another learner attempted to give an extended response by justifying her answer. Although the learner was incorrect, Mandy did not simply tell her that she was wrong (evaluating negatively) in her answer but asked her to elaborate. The learner then expanded her answer in an extended student contribution referring to one of the three conditions in the definition of population. This expansion

showed that the learner had not made meaning of the concept but was attempting to do so. Instead of correcting the learner, Mandy repeated the learner's answer to the class (using the restating move), which led to the learners arguing. This argument demonstrated that some learners agreed with the reasoning of Learner 1, while others did not (see turns 6 and 10). Learner 1 then used another condition of the term population to defend her position in an extended student contribution, this time using spatial similarity, which Mandy challenged by directly asking the learner if the class they are in is in the same environment at the same time. The learner gave a brief response of disagreement by saying "no". This answer showed that the learner had misunderstood the question. Mandy did not stop there, but used the temporal condition to challenge the learner's answer further. Mandy corrected the missed opportunity in turn 5 in turn 11 when she offered the learners the opportunity to make meaning of the term population by using a rejoinder. This rejoinder, asking the learners to elaborate on why they gave the answers that they did, allowed the learners to defend their position. When a learner gave an extended student contribution (turn 12) by justifying his answer, Mandy further used a challenging rejoinder to get the learners to see that the class they were in and the next class did not belong to the same population. When she was asked why she used these specific moves, she said:

I'm challenging those, those contributions because I want to see... So, I wanted to see if the child really understands.

Her utterances above indicate that she was guided by specific learner contributions. She specifically wanted to see if learners could make sense of the concepts at hand. Mandy then closed the episode by expressing that because

the two classes do not meet all the conditions of what a population is, they cannot be the same population. However, Mandy missed the opportunity in turn 18 to establish to the learners that the two classes may become the same population at a different time, such as during break.

In summary, Mandy used an example that emerged as a close-ended question move to assist in her teaching. She also used that example to have learners insert themselves into the concept. By having the learners immerse themselves into the context and further challenging their contributions, Mandy facilitated meaning-making for the learners by using different talk moves to not only get learners to respond but to evaluate their own responses through challenging them. She justified challenging the learners' contributions by stating challenging helped her find out if the learners understood what was being taught, showing that she used the learners' responses to guide her teaching.

Excerpt 3 also comes from the first lesson. Here, Mandy was teaching about what the term species means, following the definition and examples of a population. Although the episode shows elements of examples of populations, I have categorised it as a new episode because the concept of interest here was the term species.

Excerpt 3

Turn	Speaker	Utterance
1	Mandy:	Another perfect example. People in America at this very point, the United States of America and people in South Africa, are they the same species? Are they the same species?
2	Learners:	Yes.
3	Mandy:	Yes. Okay. Are they the same population?
4	Learners:	No.
5	Mandy:	No. I asked, are they the same species? You said yes. Why do you say they are the same species?
6	Learner 1:	Because we are <i>Homo sapiens</i> .
7	Mandy:	Why do you say they are the same species? Because?
8	Learners:	We are all <i>Homo sapiens</i> .
9	Mandy:	She says, because we are all <i>Homo sapiens</i> , which is true again. So therefore, that makes us the same species as people from America, people from India and so on. But are we the same population?
10	Learners:	No.
11	Mandy:	No, we are not the same population because we are not in the same area and in the same time.
12	Learners:	... in the same area at the same time.
13	Mandy:	Okay, now you know what is population?
14	Learners:	Yes.

As shown in excerpt 3, Mandy introduces the term species by using the different populations of South Africa and the USA. She used a literal initiation move to ask the learners if the two populations were the same species. The learners offered a brief contribution in turn 2 in the form of a single-word answer in agreement. In turn 3, Mandy then asked them if they were the same population in an attempt to see whether the learners could differentiate between species and population. The learners demonstrated in turn 4 by saying “no”. Mandy offered the learners a meaning-making opportunity in turn 5 by using a rejoinder of challenging the learners to ask them to defend their answers as to why the same species is now two different populations. Again, Mandy used an example that the learners could

relate to by immersing themselves in the scenario. A learner gave an extended contribution justifying his stance in turn 6 that both populations belong to *Homo sapiens*. By giving such an answer, the learner made meaning of the concept of species by referring to what Mandy said earlier in the lesson that all humans belong to the species *Homo sapiens* and demonstrating that although he is coming across the definitions for the first time, the terms are not unfamiliar to him. Mandy then reiterated the conditions of the term population in turn 11. Mandy then used turn 13 to close the episode by asking the learners if they now understood the term, to which the learners gave a brief contribution in the affirmative. However, Mandy does not further challenge this but moves on to the next concept. Mandy had this to say about rushing through the lesson:

I found it very hard to deliver content because I really needed to squeeze my lessons and find a way... make sure that the learners received the content.

To summarise this episode, while teaching terminology, through using the provision of information move, Mandy contrasted terms to allow learners to differentiate between terms, which facilitated understanding. Requesting learners to contrast terms allowed them to join the classroom conversation. Although she used questioning, Mandy mostly relied on close-ended questions in this episode. However, through the use of extending moves and requesting clarification at certain points (e.g., turn 9) an opportunity for meaning-making was fostered. This episode further demonstrated that a single episode could include both facilitation and inhibition of meaning-making.

In the next example, excerpt 4, Mandy was teaching the concept of species. This excerpt is an extension of episode 3, following excerpt 3.

Excerpt 4

Turn	Speaker	Utterance
1	Mandy:	Before I talk about a species, what is the species? If we say things are the same species. What do we mean by that? Do we know?
2	Learner 1:	Living things.
3	Mandy:	Living things. Oh, okay. A horse is living and I'm living. So me and the horse, we are the same species.
4	Learners:	*laughing* No.
5	Mandy:	Of course it's not true. Again, but thank you for trying. When we say we are the same species or we are different species, what are we referring to? What are we looking at?
6	Learner 2:	There's some animals.
7	Mandy:	Like what?
8	Learner 2:	Characteristics?
9	Mandy:	Learner 2 is saying characteristics. What kind of characteristics? Can you give examples?
10	Learner 2:	The difference between trees, like trees have leaves and you see, and humans don't have to leave seeds.
11	Mandy:	... he's done a very good job, because now, yes, we do look at characteristics, of course, but that's not the only thing, because we look at.
12	Learner 3:	Physical appearance.
13	Mandy:	Yes, he was referring to physical appearance as well, right? So now let's just take in terms of a horse and a donkey. They more or less have the same characteristics, isn't it? Yes, but then are they the same species?
14	Learners:	No.

In the third episode in excerpt 4, Mandy introduced the learners to the definition of the term species that she already alluded to in the previous episode (see excerpt 3). Mandy began the episode by asking the learners what they understood by the term species in turn 1 (an open-ended question). In turn 2, a learner gave a brief contribution by simply referring to living things. Mandy again challenged the learner's contribution by giving another human example, which elicited another brief contribution from the learners (turn 4). Although the learner

was incorrect, Mandy thanked him for his contribution and repeated the original question. Learner 1 gave a brief contribution in turn 8 by offering an elaboration. The learner was not confident in her answer and phrased it as a question. It might also mean that the learner was trying to think about another possible answer as she contributed before. Mandy then used the input to guide the learners in the definition of species, recognising that the learners did not know the definition, but were familiar with the term from previous experience. In turn 12, a learner gave an extended contribution by describing a similarity in the same species. Mandy used this contribution from the learner as a springboard to introduce the well-known example of the horse and donkey when teaching the concept of species (turn 13), which led to the second condition of the definition. After giving the example, Mandy did not just assume that the learners understood but asked them if the two animals belonged to the same species. Although the learners still did not have the full definition of species, they used Mandy's guidance to conclude that the two animals are indeed different species. Mandy gave the learners a meaning-making opportunity by asking them to defend their answers. Learner 1 used an extended contribution to justify her answer by referring to the second condition that Mandy used. This demonstrated that the learner made meaning of the concept because she was able to support her answer with reasoning. Mandy then rephrased the learner's answer and confirmed it as correct.

Mandy gave another example in turn 8 to further drive home the concept of species. She asked the learners for their understanding but did not allow the learners to contribute. This prevented the learners from making meaning by either asking questions or giving their input. For example, the definition of species

includes the presence of similar characteristics, but even those do not constitute a species, as Mandy demonstrated when using the example of the donkey and the horse producing a mule as an offspring. Similarly, a learner may possibly argue that people from Ghana do not belong to the same species as those from China. This, however, may not be the case because of the previous example of South Africans and Americans. Mandy went further to demonstrate that the different groups are of the same species by pointing out that they meet the second requirement of species: the production of fertile offspring. When Mandy was asked about her use of these moves, she said;

I want to know. I do this because I want to find out if they can apply, you know, if they can realise... Once, they can't even tell, like, if there's a mistake in your statement or concept, whatever that you're saying, then it's a sign for... It's an alarm for worry to say that, okay, fine. I still need to do more.

In the extract above, Mandy shared how her strategy is based on the desire to find out if learners make mistakes or still have misconceptions about the concept of species. She noted that if she finds a mistake, it would be an opportunity for her to do more in terms of questioning learners. So, the factor here is the learners displaying misconceptions, which is an indicator for Mandy to teach the concept more.

In summary, for this specific episode, Mandy used elicitations as well as asking extending questions, which are higher-order rejoinders, to provide learners with opportunities to voice their thinking and build on each other's contributions. This is an element of providing opportunities for meaning-making as learners get provided with opportunities to vocalise their thinking. A

contributing factor to this is the desire to detect learners' misconceptions and mistakes.

The next example is from the second episode in the third lesson. Mandy had just completed recapping what they did in the previous lesson. The idea of interest here was calculating the population size.

Excerpt 5

Turn	Speaker	Utterance
1	Mandy:	Yeah, we spoke about species and now we move to how to...?
2	Learners:	How to calculate population size.
3	Mandy:	I remember. How to calculate population size by direct and indirect technique, right?
4	Learners:	Yes.
5	Mandy:	What is it? The catch and release method, right? That indirect one is the catch and release method. The indirect one, isn't it? For the animals, isn't it?
6	Learners:	Yes.
7	Mandy:	And then we spoke about limiting factors to population growth, isn't it?
8	Learners:	Yes.

In this episode, Mandy was recapping what she taught in the previous lessons. In turn 1, she mentioned that they spoke about species, and the learners responded in turn 2 with another concept they learnt in a previous lesson. Mandy missed an opportunity for meaning-making in turn 3 by not asking the learners examples of how to calculate population size, instead giving the learners the examples, and asking the learners for confirmation. The learners responded in turn 4, which they used in all the upcoming contributions in this episode. In turn 5, Mandy asked what the technique was, and instead of waiting for the learners to answer, she answered the question herself, another missed opportunity. She

also gave the condition of this technique and used a rhetorical close-ended question for the learners to confirm in turn 6. She repeated this pattern in turn 6 as well, with the learners responding in the affirmative. When asked why she was not giving learners the opportunity to interact with the lesson, Mandy responded with:

I had like, very, very, very limited time. Like, if you have noticed you would realise that I taught the content very late in the term, you know.

In this extract, Mandy justified her rushed lesson by using time as a factor that caused her to not give learners the opportunity to fully engage in the lesson, thereby impeding their meaning-making process. Because she taught the topic of population ecology late in the term, this exacerbated her need to speed through the lesson before the term ended. She also mentioned contextual circumstances that contributed to this rush.

To summarise this episode, Mandy missed multiple meaning-making opportunities by not using rejoinders to ask learners to explain or give examples of what they learnt. Instead, the majority of the questions that she asked were rhetorical questions that the learners answered without the opportunity to demonstrate their understanding. The use of rhetorical questions which are close-ended. When learners tried to respond, they were interrupted in the middle of their attempt to answer. This signifies that Mandy did not give the learners enough wait time. According to Mandy, this was due to the limitation of time which forced her to speed up the lesson and focus on covering content, foregoing meaning-making for the learners.

4.4.2 Case 2: Ntando

Ntando teaches in a quintile 5 city school in a suburban area. Ntando was observed three times while teaching population ecology. Below, I present the findings that emerged from Ntando's lessons and interviews. I begin by showing the prevalence of talk moves as observed in Ntando's lessons in Table 4.6.

Table 4.5 Prevalence of talk moves in Ntando's lessons

Nature of talk moves	Category of Talk move	Sub-category of talk moves	Lesson 1: Introduction, definitions	Lesson 2: Social organisation, interactions in the environment	Lesson 3: Summary, population growth curves, population size and density	Total
Initiations	Launch	Open-ended	2	4	7	13
	Literal	Close-ended	3	2	11	16
	Providing information		0	3	1	4
Total initiations per lesson			5	9	19	33
Rejoinder	Repeat	Restating	1	0	1	2
		Marking	1	2	17	20
		Affirming	3	4	14	21
	Uptake	Reframing	0	2	6	8
		Requesting information	0	3	13	16
	Connection	Elaborating	0	4	6	10
		Revoicing	1	3	12	16
	Extending	Challenge directly	0	0	3	3
		Challenge to extend ideas	0	0	5	5
Total rejoinders per lesson			6	18	77	101

Table 4.6 above shows the prevalence of talk moves used by Ntando in her lessons. In Ntando's classroom, the learners were engaged with the lessons. They engaged by answering the questions that Ntando asked and even asked

questions of their own. This is something that Ntando actively fostered in the classroom, by encouraging the learners to ask questions and responding positively to learners' questions and responses. The prevailing initiation moves are literal moves described as close-ended questions, especially in the second lesson. In the first lesson, Ntando initiated discussions five times and nine times in the second lesson. The provision of information to initiate discussions was only evident in the second and third lessons.

In terms of rejoinders, Ntando seemed to be using the repeat move the most as seen by the totals. However, the types of repeat moves that prevailed were affirming and marking learners' responses. The uptake move was used often, especially in the third lesson where she requested information from learners 13 times. Unlike repeat moves that were used once in the third lesson, Ntando dwelled on revoicing learners' responses. In terms of extending, Ntando only challenged learners in the third lesson. This is an indication that the third lesson was the most interactive. Below, I reveal how using these moves provided learners with opportunities for meaning-making, while some inhibited this.

The following excerpt comes from episode 2 of Ntando's first lesson. In this lesson, Ntando had just finished explaining the concept of population ecology and moved to explain the definitions.

Excerpt 6

Turn	Speaker	Utterance
1	Ntando:	So a single species or a species is of the same organism that can interbreed and form offspring that can also reproduce... Yes?
2	Learner 1:	So, what about dogs?

- 3 **Ntando:** Dogs?
- 4 **Learner 1:** Can different dogs have children?
- 5 **Ntando:** Yes. You do get mixed breeds in dogs, but German shepherd can only mate with a dog that is maybe the same height as it. Isn't that so?
- 6 **Learner 2:** Huh-uh.
- 7 **Ntando:** No? Okay, well, that it's a mixed breed that the new species is called. Do you understand? So there they can they can. Okay, any other questions? New species can be formed in the environment, but sometimes that new species cannot form viable offspring.

In turn 1, Ntando provided information regarding the concept of species. As she completed her provision of information, Learner 1 in turn 2 asked an interesting question “What about dogs?” with a quest to understand the concept of species and breeding when it came to dogs. This was in response to the condition of similar characteristics. Although Ntando answered the learner in turn 5, the exchange demonstrated a missed opportunity for meaning-making because Ntando could have used that question as an opportunity to differentiate between breeds and species, which would also build on the learners’ prior knowledge for the upcoming Grade 12. Ntando could have probed the learner further by asking a question regarding species and interbreeding concerning the information provided in turn 1. Instead, she further provided information in turn 5 and only asked learners to confirm the information she provided. At the end of turn 5, Ntando asked for confirmation of what she was saying, and the learners disagreed in turn 6. Turn 5 created a misconception in the learners because Ntando alluded to some dog breeds being unable to mate, which can possibly give the learners the idea that the breeds are different species. This misconception was not addressed. In turn 7, instead of challenging the learners to elaborate on why they were disagreeing, Ntando dismissed their dissent. In the

same turn, Ntando created another misconception that a new breed constitutes a different species. This was another missed opportunity because learners may get confused and think that species and breed mean the same thing. In turn 7 still, she asked the learners if they had any more questions, but she did not wait for the learners to answer and instead moved on to the next concept. This is a typical example of how teachers can miss an opportunity to engage learners in a meaningful discussion by using rejoinder moves.

In summary, for this specific excerpt 6, Ntando did not use any initiation move as she was asked a question by a learner. Ntando missed an opportunity by not eliciting more interaction from the learner. Questions initiated by learners could facilitate meaning because they reveal that learners were cognitively engaged. Other ways in which opportunities were missed were due to Ntando not noticing or addressing learner misconceptions, as well as not clarifying some of her statements, which potentially perpetuated learner misconceptions. This episode could have led to meaning-making had Ntando used rejoinders to have the learners engage with the discussion and explore their misconceptions.

In the second example, Ntando was teaching about the idea of a social organisation. This is episode 3 of lesson 2. In this episode, Ntando had just finished a discussion on the concept of social organisation in different species. Here Ntando uses the example of honeybees to further teacher the concept of social organisation.

Excerpt 7

Turn	Speaker	Utterance
1	Ntando:	So tell me what you know about honeybees.
2	Learners:	They make honey.
3	Ntando:	They make honey. Good. How do they live?
4	Learners:	They're making pollen.
5	Ntando:	What is their social organization? I explained it to you just now.
6	Learners:	They have a queen.
7	Ntando:	They have a queen, good? They have drones and they have?
8	Learners:	Workers.
9	Ntando:	Workers. So the queen is the only one that reproduces. She mates with the drones. The workers. What do the workers do?
10	Learner 1:	Work.
11	Ntando:	So if the queen dies, then they will pick another one. Yes?
12	Learner 2:	What if there are two queens?
13	Ntando :	In one hive, there's only one queen. Okay? Okay.

What can be seen in excerpt 7 above is a chain of interaction where most learners were involved through chorus responses and two learners through individual responses. In turn 1, Ntando used a launch initiation move to ask an open-ended question that was expected to spark an interaction. The assumption here is that learners' responses would be entertained given the possibilities of open-ended questions (Schindler et al., 2018; Smart & Marshall, 2013). Furthermore, the expectation was that this question would allow learners an opportunity to explore their ideas. Learners then provided a chorus response in turn 2, to which Ntando used the repeat rejoinder move to the learners' contribution by affirming it. In line with the IRE/F interaction approach (Friend, 2017), Ntando would have stopped there and continued with her explanation. Instead, she used an uptake rejoinder to request information from the learners in turn 3, and continued to use a similar uptake move by rephrasing the question in turn 5 when the learners continued

to answer with brief student contributions, instead of elaboration by directly asking the learners for the social organisation of bees. Ntando missed an opportunity to correct the learners when in turn 4, a learner asserted that bees make pollen, which is a misconception and because Ntando did not address it, the learner will continue to have that misconception. Learners answered with what Ntando considered the correct answer (seen by an affirmation in turn 9). However, she did not stop there. She further asked what workers do then affirmed again in turn 11. On the surface, one would argue that this is a typical authoritative interaction pattern. Although it does have an authoritative aspect when learners chorus the answer, through affirmations and probing further, Ntando tapped into learners' thinking about what they could have already known about bees. This is evident in turn 12 when Learner 2 asks a further question as an indication that he was thinking about what they have discussed. Instead of asking further questions in turn 13, Ntando closed the interaction by answering Learner 2. While teaching about social organisation, Ntando used the example of bees. Ntando did not use negative feedback to the learners' incorrect answers, but instead either rephrased the question or asked the learners to think about it more. After further explanation and questioning from both the teacher and the learners, the learners showed an understanding of the concept of social organisation and the division of labour in a population. When asked why she used an example that the learners would know, Ntando had this to say:

So, they, the most important thing is that they need to understand the concepts that are being taught. So, to ask them leading questions which will link what they know to what I'm trying to teach them.

As seen in the above extract, Ntando stressed how important it was for the learners to understand the concepts that she was teaching. One way in which she would get the learners to understand the concepts she was teaching was to link what the learners already knew with the concepts. This is because linking previous knowledge is a signifier of meaning-making.

In summary, in this specific excerpt, although there were some opportunities to drive meaning-making, there were missed opportunities as well when Ntando did not address the learners' misconceptions. Ntando used affirming moves as well as extending moves to drive the interaction for meaning-making. Affirming moves can facilitate meaning-making as learners get an indication on whether they are correct. Her reasoning for asking leading questions can be considered as an enabler or inhibitor of meaning-making.

The third example (excerpt 8) comes from the first episode in the third lesson. In this excerpt, Ntando was revising with the learners the concept of species, that she had taught in the first lesson, and was moving on to a discussion of the concept of species.

Excerpt 8

Turn	Speaker	Utterance
1	Ntando:	So what is a species? Can someone explain to me what is a species?
2	Learner 1:	Animals!
3	Learner 2:	A species with similar characteristics.
4	Ntando:	Is that all? Ok, you've given me half the definition. Can you expand on it?
5	Learner 3:	They are able to interbreed to make fertile...
6	Ntando:	So can you say the full definition?
7	Learner 4:	A group of species that have similar characteristics and are able to interbreed to give fertile offspring.

- 8 **Ntando:** Ok, good. You used the word species in the definition. So it's a group of?
- 9 **Learner 5:** Organisms.
- 10 **Ntando:** Organisms. It's a group of similar organisms with the same characteristics that are able to interbreed randomly to form viable, fertile offspring.
- 11 **Learner 6:** Viable?
- 12 **Ntando:** Yes, what is viable?
- 13 **Learner 3:** Alive.

In the above excerpt, Ntando used a launch initiation move in the form of a closed-ended question to ask the learners to define a species in the first turn. Learner 1 responded abruptly with a short response in turn 2 and another learner, Learner 2, immediately followed with what can be considered a brief contribution as well. Instead of evaluating the two learners' responses, Ntando used the uptake rejoinder by asking the learners for more information in Turn 4. Not only did she seek more information, but also provided learners with a repeat rejoinder by marking the learners that their responses did not define what a species means. Although this may show that Ntando was looking for a specific response, she did not immediately provide them with the definition she was looking for. Instead, she prompted the learners to give the full definition in turn 6, which led to Learner 4 providing a correct definition in turn 7. In turn 8, Ntando evaluated Learner 4's response by marking it as correct; that it was the answer she was looking for. However, she noticed that Learner 4 used an incorrect term and then followed that up by asking a leading question to which Learner 5 provided a correct term (see turn 9). What is important to note here is that Learner 5 was quiet all along but spoke up in turn 9. This indicates that Learner 5 was in the process of internalising the definition given by Learner 4 in turn 7. Ntando then provided a

full definition in turn 10 and Learner 6 asked what the term viable meant. Again, this indicates that the learner was also internalising what unfolded during the discussion up to that point. In addition, instead of Ntando providing a straightforward response on the term viable, she redirected the question to the rest of the class and Learner 3 responded (see turn 13). This constituted meaning-making because although Ntando was in an authoritative role and guiding the learners, their interaction displayed a willingness to get to the answer, and not be discouraged when they did not immediately get it correct. The learners were guided to the answer, instead of being spoon-fed one.

During the interview, Ntando was asked about her persistence in asking further questions and redirecting learners' questions back to them. She said:

My understanding of that is that you need to have a proper, good relationship with the learners in order to make them feel comfortable so that they can actually ask questions without feeling threatened or intimidated by me. So to get them into an environment which is friendly but firm so that they can actually feel that they are able to tell me when they don't understand something or if they are unsure about something, that they won't feel threatened... in a way that they wouldn't make them feel threatened to ask questions later on.

In Ntando's comments above, what can be gathered is the issue of relationship with learners. Specifically, her utterances reveal that her persistent use of moves was influenced by her perceptions about the role of questioning – that it gives learners a view that one is interested in their responses. She does this so that the learners remain interested in the topic and are not “turned off” from engaging further in the lesson due to negative feedback from her, as shown in extract 6. Ntando mainly used positive language when engaging with the learners. At different points, she thanked the learners for their contribution and

responded to their contributions positively. Even when the learners were wrong, she mostly refrained from saying they were wrong outright. Instead, she redirected them to the correct answer. Ntando expressed the view that positive language encouraged the learners to feel confident enough to interact in the classroom and share their own ideas.

Regarding letting learners build on each other's contributions, Ntando had this to say:

It actually made me aware that I wasn't doing that. And then I tried to do it in the next lesson because I actually did not. I did not use their contributions. And also, previously I would just give them the answer.

In the above extract, Ntando admitted that she was not aware that she was not letting learners build on each other's contributions, which she corrected in her lessons. She further mentioned that before that, she would give the learner the answers, instead of prompting them like she did in the excerpt, which she addressed.

In summary, Ntando used positive evaluation, redirecting questions back to the class, as well as asking extending questions to provide learners with an opportunity to voice their ideas. This brought learners into the discussion who had been silent at the beginning. This episode provided multiple meaning-making opportunities for the learners as they eventually got to the concept without being given the answer, with Ntando's prompts. Ntando's use of discursive moves was supported by having built a conducive environment for learners to engage in the classroom.

The fourth example (excerpt 9) is episode 5 from lesson 3. Here Ntando had just finished teaching about density-dependent factors that affect population size. The transition point to this chain of interaction was a learner asking a question about a factor that affects population size.

Excerpt 9

Turn	Speaker	Utterance
1	Learner 1:	I have a question, teacher. How can an earthquake cause a population to decrease?
2	Ntando:	How can it cause the population to decrease? What if members of the population fall into the ground?
3	Learner 2:	Yes.
4	Ntando:	Then they'll die. So the population size will decrease.
5	Learners:	Murmuring
6	Learner 3:	Can I answer them? Can I answer you guys?
7	Ntando:	Okay, go ahead...
8	Learner 3:	It will also decrease because like it also damages property, when property gets damaged, habitats get damaged and so because of that, the people or the population gets damaged as well.
9	Ntando:	So remember we are not only talking about the human population. We're also talking about population of other species in nature.
10	Learners:	Yeah.
11	Ntando:	We're also talking about population of other species in nature. Yes. So human population also die when there's an earthquake.
12	Learner 1:	How?
13	Learner 2:	A building falls on top of you.
14	Learners:	[Discuss the answer. Unintelligible.]
15	Learner 1:	I understand you now.
16	Ntando:	You understand? Ok.
17	Learner 1:	Thank you, geography learners.

The learner's extended question in turn 1 is a typical indication that this learner was thinking about earthquakes which was the concept of interest before this interaction. As noted earlier in Chapter 2, initiations from learners indicate

meaning-making. Instead of Ntando providing a response in turn 2, she redirected a question to the class, which led to Learner 2's brief student contribution response in the affirmative. What is interesting in this excerpt is Learner 3's contribution in turn 6, where she was showing a willingness to answer. This indicated a dialogic/interactive pattern in this episode. In turn 7, Ntando provided the learner with an opportunity to voice her contributions. Learner 3 then answered, using her knowledge of the subject of Geography. In this regard, the learner was able to make links between different subjects, thus showing an ability to make meaning. Ntando then pointed out that Learner 3's answer was centred around human beings, which made sense considering where they drew their prior knowledge, but it must extend to other organisms as well. When another learner still expressed confusion, the learners worked cooperatively to get the learner to a point of understanding (shown in turns 12 through 15). Therefore, a key point here is learners' ability to respond to each other's questions during interactions and to help each other make meaning of a concept by using their knowledge from other subjects, indicating that meaning-making can also arise from collaboration. However, the teacher played a role in facilitating the interaction by requesting clarification and asking extended questions.

In summary, for this specific excerpt, Ntando entertained the learners' initiated questions coupled with her rejoinders and provision of information to allow further explanations from learners. She used the learners' willingness to engage with each other to get learners to make meaning. This indicated that the learners can also be drivers of meaning-making through linking knowledge from other subjects to supplement their learning of Life Sciences concepts.

The fifth example (excerpt 10) comes from episode 8 of lesson 3. In this excerpt, Ntando had just discussed the factors that led to the human population growth being exponential, with one learner noting that medication has improved people's quality of life so that they can live longer and reproduce, because of the factor of medical advancements.

Excerpt 10

Turn	Speaker	Utterance
1	Ntando:	Have enough medication to keep healthy and have enough food and beautiful homes in which we can live in, even though the environmental like last night there was a storm, but we were in our homes, we were not affected by it.
2	Learner 1:	Teacher, what about homeless people?
3	Ntando:	Sorry?
4	Learner 2:	The roofs, teacher, of the houses.
5	Ntando:	Really?
6	Learners:	Yes.
7	Ntando:	Where was that?
8	Learners:	[Inaudible]
9	Learner 3:	Teacher, a tree fell.
10	Ntando:	Ok, guys, that is a perfect example that we are not exposed to the environmental conditions. If we were not in homes, if we did not, it were not technologically advanced and we could not build our own homes and we could not have heaters and we could not have electricity. Imagine it would have been exposed to the environment, we wouldn't have been able to. Our population would be de?
11	Learners:	Decreasing
12	Ntando:	Decreasing. Because we would die because of the external conditions. You understand? That's what we mean when we say technological improvements. Yes?
13	Learner 1:	Regarding the wind yesterday, what happens to the street kids and street adults when the wind is blowing?
14	Ntando:	The street kids?
15	Learner 2:	Homeless people.
16	Ntando:	Yes! That's the problem. Exactly. They don't have homes, and if they did have homes.

So that's what we are saying. Because we're technologically advanced, because we have these technological advancements we are not exposed to environmental conditions. So that's why our population is growing indefinitely because we are not subjected to the environment.

- 17 **Learners:** Yes.
- 18 **Ntando:** With us there is it. We have overcome the environmental crisis because of our technological advance, you understand?
- 19 **Learner 2:** Homeless people?
- 20 **Ntando:** Yes, those people are now exposed to the environment, but fortunately we have welfare people that could take care of them. We look after each other, isn't that so?
- 21 **Learners:** Yeah. Yes!
- 22 **Ntando:** Yes.
- 23 **Learner 4:** There are orphanages and shelters.

In turn 1, Ntando used the example that houses assisted in humans increasing in population because they provide shelter from the harsh environment. A learner challenges this in turn 2 by asking about those who do not have houses to shelter them. From turn 4 to turn 9, the learners give accounts of a previous experience the night before, which was a storm and how it damaged property. The learners were attempting to convey that they did not fully understand the factor that houses can fully shelter humans from environmental conditions. Ntando saw the opportunity for the learners and explained the link between technological advancement and building homes to the human population in turn 10. She then used a literal initiation move to drive home this point. Although it led to some interaction, this discussion took the focus away from Learner 1's question and did not lead to meaning-making. Learner 1 rephrased his original question from turn 2 in turn 13 (evidence of meaning-making). Although Ntando did not fully answer the learner's question, she reiterated that homes have led to an increase in the

human population. Learner 2 was still unsatisfied with Ntando's answer and continued to repeat Learner 1's question (turn 19), showing that she was attempting to make meaning, but could not do that without answering the question, as she did not understand how the existence of homeless people could be ignored. Ntando finally answered Learner 1's original question in turn 20 by using an uptake rejoinder. The learners affirmed this in turn 21, and learner 4 confirmed that he understood by giving an example. By giving examples, the learner demonstrated this understanding as a product of Ntando's rejoinder. It is important to note that the learners made meaning by linking the concept being taught with their own experiences and the experiences of others. When asked about their incorporation of real-life issues in her lessons, Ntando responded with:

I didn't really [incorporate real-world issues]. And I've been trying to read up because now these interviews that you're doing is like, making me think more about how I'm going to be teaching the population ecology. And I've been reading more to find more real-life situations.

In the above extract, Ntando did not recognise that she used real-life situations and experiences while teaching. This indicated that Ntando was not aware of some of her own strategies to afford learners meaning-making opportunities. However, the learner questions as seen in the excerpt drove the interaction for meaning-making.

To summarise the above episode, the learners showed cooperation and a desire to help each other make meaning by drawing from their experiences and using their knowledge of other subjects to supplement what they were lacking in their Life Sciences knowledge. Learners demonstrated a willingness to build on each other's responses using experiences and knowledge gained from other subjects,

which was the primary meaning-making factor in this episode. The teacher provided this opportunity by asking the learners questions regarding those experiences. This reassured the learners that they were not veering off-topic with their contributions. Although she had a hand in this meaning-making from real-world issues, Ntando did not seem to be aware of this.

4.4.3 Case 3: Tebogo

Tebogo teaches in a quintile 1 rural school. Tebogo was observed three times while teaching population ecology. Below, I present the findings that emerged from Tebogo's lessons and interviews. I start by presenting the prevalence of talk moves in Tebogo's lessons in Table 4.7.

Table 4.6: Prevalence of talk moves in Tebogo's lessons

Nature of talk moves	Category of Talk move	Sub-category of talk moves	Lesson 1: Introduction to population ecology, definitions	Lesson 2: Human population, interactions in the environment	Lesson 3: Population growth curves, social organisation, predation, recap	Total
Initiations	Launch	Open-ended	9	5	6	20
	Literal	Close-ended	2	1	2	5
	Providing information		2	1	2	5
Total initiations			13	7	10	30
Rejoinder	Repeat	Restating	0	0	3	3
		Marking	1	1	3	5
		Affirming	2	3	3	8
	Uptake	Reframing	2	1	0	3
		Requesting information	3	2	0	5
	Connection	Elaborating	1	3	1	5
		Revoicing	5	5	6	16
Extending	Challenge directly	0	1	1	2	

		Challenge to extend ideas	0	1	1	2
Total rejoinders per lesson			27	24	28	79

As shown in Table 4.7, Tebogo used different talk moves during his lessons. The lessons have a similar structure in the kinds of talk moves he used, and how often. His most prevalent initiation move was the Launch move in the open-ended sub-category, with a total of 20 of these moves for all the lessons. The most prevalent rejoinder move was revoicing what the learners had said, a form of echoing, with a total of 16 in all three lessons. The least prevalent talk moves were extending rejoinders. Tebogo only challenged the learners' contributions twice in a lesson, and zero times in his first lesson. The total number of talk moves for each lesson was less than 30, and all talk moves in Tebogo's lessons added up to 79. Tebogo's lessons are dominated by non-interactive authoritative classroom talk.

Excerpt 11

Turn	speaker	Utterance
1	Tebogo:	Can we please recap what we said species are? What did we say species are?
2	Learners:	A group of organisms that...
3	Tebogo:	A group of organisms that share similar?
4	Learners:	characteristics
5	Tebogo:	Characteristics. That one is important, that you show that they share similar...?
6	Learners:	Characteristics
7	Tebogo:	Characteristics, ok? So meaning, they share similar characteristics meaning they can do what? To interbreed and produce fertile offspring.
8	Learners:	(simultaneously) To interbreed and produce fertile offspring.
9	Tebogo:	Ok. So meaning an organism that is not able to produce a fertile means that it's not the same? Species.

The above excerpt is the first episode of Tebogo's second lesson. In this lesson about the definition of a species, Tebogo asked the learners for the definition of the term in turn 1 using a literal initiation move. Tebogo did not allow the learners to complete the definition on their own, but instead guided them to the answer by giving the learners the next word in the definition (turn 3 through turn 8), and the learners repeated what he said. He stressed the importance of one of the conditions for species, and then, instead of offering the learners the opportunity to complete the definition, he did it for them. Although defining terminology constitutes rote learning, meaning-making can still take place if the learners can connect the definition with specific examples, an opportunity they were denied. Furthermore, by completing the definition for the learners, Tebogo prevented the learners from learning by making mistakes, taking away their autonomy in the learning process. What is also concerning is that this is a recap lesson, wherein the learners were supposed to already know the definition of species but were not allowed to demonstrate that knowledge because of how Tebogo drove the authoritative interaction.

To summarise this episode, Tebogo used a trickle method of guiding the learners to the answer. Asking leading close-ended questions put a wall on learners' thinking, thus inhibiting opportunities for meaning-making. This type of questioning prevented the learners from making meaning because they were not given a chance to complete their thoughts, especially since this episode was recapping what had already been taught. Another way in which meaning-making was prevented was that Tebogo did not make use of examples in the form of either initiation moves or rejoinders to drive home the concept he was teaching.

In the next excerpt, Tebogo uses an infographic to support his teaching of symbiosis. This image is shown below in Figure 1. This is from episode 3 of his second lesson.







INTERACTION	TYPE OF SYMBIOSIS	EXAMPLE
 <p>Benefits Benefits</p>	<p>Mutualism Species A benefits Species B benefits</p>	 <p>Sea anemone Clown fish</p>
 <p>Benefits Unaffected</p>	<p>Commensalism Species A benefits Species B unaffected</p>	 <p>Whale Barnacle</p>
 <p>Benefits Harmed</p>	<p>Parasitism Species A benefits Species B harmed</p>	 <p>Dog Tick</p>

Figure 4.1 Infographic on symbiosis

Excerpt 12

Turn	Speaker	Utterance
1	Tebogo:	So you can see, it's not like clear, clear but it's visible right? mutualism, you can see that, can you see the pictures there, they are both smiling meaning who is benefitting?
2	Learners:	Both
3	Tebogo:	They are both benefitting. So meaning, in mutualism is where both organisms are benefitting. So you can add under mutualism there that they are both benefitting. Commensalism. Can you see commensalism? The second one?
4	Learners :	Yes.
5	Tebogo:	So what do you think happens during commensalism?
6	Learner 1:	The one is benefitting while-
7	Tebogo:	The one is benefitting?
8	Learner 1:	While the other is being harmed.
9	Tebogo:	The other one is...?
10	Learners:	Harmed.
11	Tebogo:	For commensalism, one benefits
12	Learners:	It's not harmed.

In this episode, Tebogo used visuals to supplement his lesson on symbiotic relationships. In turn 1, Tebogo used the image to make a literal initiation move.

Although the learners gave the correct answer, Tebogo could have challenged them to ask how that would be the case, because the learners used the cues from the image to guide their answer but did not show any understanding of how that would be. In turn 3, Tebogo made another literal move, but instead of waiting for the learners to answer and demonstrate which one he meant by commensalism, he gave them the answer, to which the learners gave a brief contribution in the affirmative. Tebogo then used a launch initiation move in turn 5 to ask the learners' thoughts on commensalism. This could have been a meaning-making opportunity, but as the learners were attempting to give the answer (turn 6), Tebogo interrupted them in turn 7 to repeat what Learner 1 was saying. In turn 8, the learners completed the answer, and Tebogo used an incomplete sentence to have the learners repeat the answer, which was done again in turn 11. This episode demonstrated how meaning-making can be inhibited when the teacher does not allow learners to complete their answers, or even learn from their mistakes. When asked about questioning, this is what Tebogo had to say:

I think if I ask questions that is going to stimulate discussion and class, it's going to allow students to be out of the box. They're going to be creative, and also I'm going to understand are they really understanding what the content is about? Because when I question them, it's going to be easy to see if they do understand the concepts and also I'm going to be able to identify gaps and see if they're on the right track.

In an interview, Tebogo expressed the importance of questioning as it helped him with understanding how much the learners understood about the topic being taught. This was not reflected in the lessons, as Tebogo mainly used rhetorical or

close-ended questions when giving a lesson. When asked a question, the learners generally gave a brief student contribution in the form of a single word, or an extended student contribution by simply reiterating what Tebogo had said earlier in the lesson. These types of contributions do not demonstrate thinking creatively, as was Ntando's intention, but rote learning. These interactions indicate missed meaning-making opportunities because the learners were unable to give their input or relate the content with their prior knowledge or experience regarding the topic at hand.

In summary, Tebogo missed an opportunity by not exploiting the image he was using. He did not probe the learner further to check for understanding or whether the learner was simply answering by what they saw on the image.

Excerpt 13 below is coming from episode 1 of Tebogo's third lesson. This episode is about human population and the factors that led to its exponential growth.

Excerpt 13

Turn	Speaker	Utterance
1	Tebogo:	So we're gonna be looking at these graphs. The age population graphs. So when you talk about evolution, do you understand what we mean?
2	Learners:	Yes.
3	Tebogo:	Yes. Modern humans have been evolving, ok? Do you understand
4	Learners:	Hmmm
5	Tebogo:	The second reason is medicinal improvement. For example, HIV, when you compare with the olden days and now, you can see that more people are surviving HIV than the ones in the olden days, do you understand?
6	Learners:	Yeah
7	Tebogo:	That is what I mean, that in medicine there are more medicines, when you compare it to olden days.

Then we have a declining population pyramid, obviously if something is declining it means it's obviously?

As shown in the excerpt above, there are multiple instances where Tebogo talks for extended periods (turns 1, 3, 5 and 7), which were broken by learners assenting to the seemingly rhetorical question of "You understand?" or Tebogo asking predominantly literal initiation moves to ask the learner questions and not allowing the learners to answer them, by answering it immediately after asking. When he gave the learners the answer, Tebogo prevented the learners from making meaning of the content in this authoritative episode, as was common in most episodes of Tebogo's lessons. Tebogo also asked questions but did not allow the learners the opportunity to respond but simply continued with the lesson. This lack of wait time prevented the learners from engaging with the content.

To summarise the above episode, although Tebogo asked questions, they were rhetorical and did not allow the learners to make meaning. These questions were also posed after Tebogo had given the learners a lot of information, which could have distracted the learners and not know how to answer when asked whether they understood what Tebogo had just said. The excerpt also showed that Tebogo did not give his learners enough wait time to give their contributions.

In the excerpt below from his final lesson and fourth episode, Tebogo is recapping symbiosis with the learners.

Excerpt 14

Turn	Speaker	Utterance
1	Tebogo:	So the parasites may benefit, but the host will be harmed. Ok? Give me an example of parasitism.

- 2 **Learner:** Murmur
3 **Tebogo:** Just like, a day-to-day example. Dog and a?
4 **Learner 1:** Tick
5 **Tebogo:** A tick, ne? a dog and a tick, right? meaning which one is
 parasite between the two?
6 **Learners:** The tick
7 **Tebogo:** The tick, right? So the tick is parasitising, huh?
 Parasitising

In the above episode, Tebogo used the two initiation moves: providing information and a launch move in turn 1 to ask the learners an open-ended question about an example of parasitism. The learners began by mumbling incoherently as shown in turn 2, signalling their lack of confidence in answering the question. Tebogo noticed this and gave the learners a part of the answer, which was one of the parties in a parasitic relationship, to which one learner responded with a brief answer of the word 'tick' in turn 4. Although his answer was short and may be from remembering the image depicting parasitism in Figure 1, it did demonstrate that the learner had internalised information from a previous episode and was attempting to make meaning of the concept of parasitism by being able to identify that a tick harms the dog while benefitting. Such interactions were rare in Tebogo's lessons, which went against what he said previously in the interview that he encourages discussion in the classroom. When asked about the lack of discussion, Tebogo responded with:

So now population ecology, when we, when we teach it during that time, it's the time where we are too much focused on matriculants. So I think that also, it also doesn't allow us to have more time because during that time, if you teach in grade eleven and also teaching grade twelves, that is when mostly they always, at school, they always press us on and push us to focus mostly on the grade twelves and we don't have enough time to cover everything. And you will note that the topic was covered in just a few lessons.

The rarity of discussions in his lessons is explained by Tebogo's answer in the interview that he had to rush through the lessons because he did not have time, as he was instructed to prioritise the Grade 12 learners over those in Grade 11. This was detrimental to the learners in two ways: they did not get to make meaning of the concepts being taught, and this will affect them in Grade 12 when they will need their Grade 11 knowledge of population ecology when learning evolution.

The above demonstrates that learners did try to make meaning out of symbiosis, but were not afforded the opportunity to do so through the interruption of their contributions. Tebogo explained that that was the case due to the pressure of being instructed to focus on Grade 12 learners, which led to the neglect of Grade 11 learners, reducing the time he was able to teach the topic, and causing him to rush through the lesson to attempt to cover the content, foregoing the learners' understanding.

4.5 Summary of findings

Mandy used a lot of talk moves in her lessons. The most prevalent of these were open-ended initiations and challenging rejoinders. She justified this by stating that she wanted to see if the learners understood. Mandy also used the learners' contributions to direct her line of questioning. In doing so, she facilitated multiple meaning-making opportunities for the learners, although this was not always the case. The main factors in Mandy's lessons for meaning-making were her use of real-life examples that situate the learners in the scenarios, challenging the learners, and allowing them to build on each other's contributions. The factors that inhibited meaning-making in Mandy's lessons were her use of close ended

questions, not following up on learner contributions, and not offering enough wait time.

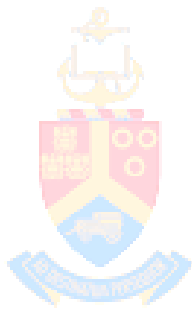
Ntando facilitated meaning-making through using real-life experience and learners' prior knowledge of not only Life Sciences, but other subjects as well. She engaged the learners using a positive tone, saying it prevents them from disengaging. The factors that led to meaning-making in Ntando's lessons were that she allowed learners to ask questions and encouraged them by using positive talk. She also used learner experience and prior knowledge to facilitate meaning-making. Although there were multiple meaning-making opportunities, Ntando missed some of these. This was most prevalent when she did not notice and address learner misconceptions about population ecology.

In the lessons that Tebogo gave, there were multiple missed opportunities for meaning-making, more than those afforded to the learners. These missed opportunities stemmed from a range of factors, including Tebogo answering his own questions, interrupting the learners' answers and completing the answers for them by not giving them enough wait time, and asking closed-ended questions that mostly had 'yes' or 'no' as answers. However, the largest inhibitor to learners making meaning of population ecology in Tebogo's classroom was that Tebogo, despite mentioning how he valued life experience in teaching and learning, did not incorporate that in his lessons.

4.6 Chapter Summary

This chapter detailed the data of the present study. In it, I detailed the use of talk moves by the different teachers, instances where the teachers offered their learners meaning-making opportunities and where the teachers hindered those

opportunities, and the factors that influenced these. In the next chapter (Chapter 5), I discuss the findings and implications of this study and conclude the dissertation.



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CHAPTER 5: DISCUSSION AND CONCLUSION

5.1 Introduction

In this chapter, I start by discussing the results of the study presented in Chapter 4 and how these answer the research questions that were asked in Chapter 1. In the following sections, I detail the significance, limitations and recommendations that arose from this study, respectively. After discussing these, I detail my reflections on the study and then conclude the chapter.

This study had a main question, which was:

How do Life Sciences teachers use talk moves to afford learners with meaning-making opportunities when teaching population ecology?

This main question was divided into three sub-questions:

1. What talk moves do the Life Sciences teachers use when teaching population ecology?
2. How do the talk moves that teachers use in the classroom facilitate meaning-making (or not) of population ecology content?
3. What factors contribute to the teachers' use of talk moves in the classroom to facilitate meaning-making?

5.2 Discussion of findings

In this section, I discuss how the data and findings presented in Chapter 4 answer the research questions as presented, and how these answers contribute to the main research question that guided this study.

5.2.1 Talk moves that Life Sciences teachers use when teaching population ecology

As seen in Tables 4.5, 4.6, and 4.7 (in Chapter 4), the teachers used a wide range of talk moves to teach population ecology. The teachers used both categories of talk moves: initiation moves and rejoinders, as described in previous chapters.

Initiation moves were used as conversation starters (Correnti et al., 2015; Galegane, 2019) in the different lessons that the teachers gave. The initiation moves were split into three groups based on their descriptions: literal, launch, and providing information. The literal moves were used to ask questions that mostly had short, direct answers that did not require elaboration. These were used to get the learners to recall information that was related to the concept at hand, as shown for example in excerpt 3 in Mandy's lessons and excerpt 10 in Tebogo's lessons. In this way, the teacher used these moves as a way to ensure the learners were following the lessons if they could answer these questions correctly. The teachers used the literal moves, especially in their introductory lessons when teaching terminology, as in excerpt 6 in Ntando's lesson. Since the literal move is a closed question, it works well when terminology is being taught because it is asked in search of a specific answer (Lee et al., 2024), which in this case would be the definition of said term.

The launch moves were used to ask open questions that required elaboration or explanations as answers from the learners (Correnti et al., 2015). These were the 'how' and 'why' questions as posited by Webb and Jones (2009), although these were used less frequently than other moves. These probing 'how' and 'why' questions invited the learners to share their thoughts and ideas with the teacher

and the rest of the class regarding population ecology. The engagement from the learners showed that they were critically thinking about the concepts and were attempting to make meaning of them. These launch moves are seen most often in Ntando's lesson, such as in excerpts 6 and 9.

The last type of initiation move that was used by the teachers was to provide information to the learners. This information was necessary for situating the learners in the concept being taught and directing their thinking, guiding them to the answer, for example, in excerpt 10 in Ntando's lesson. Another example of this move is when Tebogo used the infographic (Figure 4.1) to give the learners information so they could deduce that he was referring to mutualism. By being provided with information, the learners were able to navigate their way to the answer. This is in line with existing literature regarding the use of provision of information move (Correnti et al., 2015). Combining verbal and non-verbal initiations is not surprising, as Khoza and Makgata (2024) have shown that non-verbal initiations can also be used to invite learner contributions. All these initiation moves led to engagement from the learners to some degree. This is in line with the assertion made by Rachomas and Trakulkasemsuk (2014) that initiations stimulate learner talk, which allowed the teachers to use rejoinder moves.

The teachers also used a plethora of rejoinders in their lessons, as seen in Tables 4.5, 4.6, and 4.7 in Chapter 4, particularly in their consolidation lessons where they went over content that they had covered in previous lessons, for example, in excerpts 9 and 10 of Ntando's final lesson. This is in line with the research of Khoza and Msimanga's (2022), who found that science teachers' persistent use

of rejoinders enabled them to sustain interaction patterns. These interaction patterns allowed learners to engage more and build on their ideas. Ntando used the most rejoinders (Table 4.6), while Tebogo used the least (Table 4.7). The most common rejoinder move was the connection revoicing rejoinder move. The different teachers used the repeat moves to restate, mark, or affirm the learners' contributions. Restating learners' contributions was used, especially when a learner was not clear in his or her contribution, to invite other learners who did not hear the original contribution from the first learner. The teachers also used the restating moves when they noticed learners had misunderstood their initiation moves, as in excerpts 2 and 3 of Mandy's lessons. This was particularly evident in the case of Mandy, who restated her questions but used emphasis on certain words to guide the learners' thinking.

This finding echoes what Scott (1998) found, that such moves direct the learners to making meaning of science concepts. The marking rejoinder was shown by phrases such as "No," and "That's correct." These were useful in directly letting the learners know whether their contributions were correct. The affirming move was used to offer learners positive feedback on their contributions. This move included phrases such as "Thank you for trying," "Well done," and "Good," among others. Such moves gave learners the indication that they were on the right track in their thinking, or even that their contribution was appreciated. This positive feedback had the effect of encouraging learners to participate more, as was the hope of Ntando, which supports the assertion made by Binu (2020).

The second type of rejoinder move that the teachers used was the uptake move. This encompassed reframing as well as requesting information (Lee et al., 2021).

The teachers reframed their questions when they detected that the learners misunderstood what they had said, or when learners gave technically correct answers to ambiguous questions, and the teachers needed to phrase their question differently such as in excerpt 7 of Ntando's lesson when she asked, "What do you know about honeybees?" while teaching social organisation. When she asked the learners this question, the learners answered in a way that she did not expect, a way that was not related to social organisation, and Ntando had to reframe the question so that the learners had a clearer understanding of what they were supposed to answer. This kind of practice is desirable, as noted by Khoza (2023), as for teachers to deal with learner misconceptions, they have to follow up on learners' responses after noticing the inherent messages in those responses.

The second uptake move was to request information from the learners when their contributions were incomplete. When this move was used, it was to help the learners understand that although they were on the right track, they were still missing crucial aspects of the answer and required the teacher's guidance. This move was useful in Ntando's lesson when a learner spoke of a storm that had occurred in excerpt 10, and Ntando asked the context of the occurrence to gain information about it to help her answer the questions from the learners. This move encouraged the learners to think more on the lesson and to find solutions as they engaged. Asking for information allowed Ntando to unpack the learner's contribution to allow her to facilitate meaning-making through the extension of dialogue. This finding is similar to that of Soysal (2021), that the teacher uses information from the learners to direct the lesson in the science classroom.

The third type of rejoinder move is the connection move which was split into the elaborating and revoicing moves. The elaborating move involved having the learners say more or elaborate on their contribution (Kirk et al., 2024). An example of this is when a learner in Ntando's class asked about dogs, in excerpt 6, during a section on species. Ntando responded with, "What about dogs?" to get the learner to elaborate on his initially vague question. This pushed the learner to be more specific about his question, which helped the teacher in offering a satisfactory answer to the learner's ambiguous question.

The revoicing move can easily be confused with the restating or rephrasing moves, but serves a different purpose. This move was used to summarise the learners' contributions by aligning them to the syllabus by replacing common words with biological ones or substituting incorrect biological terms with correct ones in an otherwise correct statement (Carpenter et al., 2020). This move was mostly used when teaching terminology, as definitions require specific wording to be correct, as seen in excerpt 4 in Mandy's lesson and excerpt 8 in Ntando's lesson. The revoicing move was used a lot when learners used erroneous terms while defining the term species, such as when the teacher replaced "physical appearance" with "characteristics" in the definition. This finding supported that of (Khoza, 2024) that learners may understand a concept, but do not have the terminology to describe it. By replacing words with more scientific ones, learners got a clear indication of which words to use in specific concepts, allowing them to incorporate biological terms into their thinking. Such a move was not used in Tebogo's lessons. The incorporation of biological terms led to meaning-making

as the learners then understood what is required from them regarding specific terms.

The last type of rejoinder that the teachers used was the extending rejoinder, split into challenging learners directly or challenging them to extend their ideas. By challenging learners directly, the teacher indicated that the learners should evaluate their thinking to make it more fitting to the concepts being taught. Haber (2020) noted that critically examining their ideas leads learners to meaning-making. An example of this was when a learner in Mandy's class said that a species entailed living things (excerpt 4), and the teacher challenged her by comparing herself with a horse and asking if she and the horse were the same species since they are both living things. By doing this, Mandy did not just claim that the learner's contribution was incorrect, but demonstrated how this was the case. This exchange allowed for meaning-making because the learners were able to incorporate what they already know into the lesson.

Challenging the learners to extend their ideas engaged the learners on a new level. When the teacher challenged a learner, other learners joined in on the conversation and gave their own contributions. This was evidenced in Ntando's lesson in excerpt 9. Challenging learners is a form of questioning to extend their ideas was typically marked by the teacher answering the learners' questions with a question of her own (Chin, 2007). In this study, challenging moves were seen often, for example, when talking about how an earthquake affects population size in excerpt 9 in Ntando's lesson; this got the learners to think more about their contributions and form an understanding.

5.2.2 How the talk moves that teachers use in the classroom facilitate meaning-making of population ecology

The assumption in facilitating classroom interactions through the talk moves is that learners would respond and the teacher would follow up on the learners' responses (Correnti et al., 2015). In this study, the three teachers initiated interactions and followed up on learners' contributions to facilitate meaning-making (or not, in some cases).

Firstly, meaning-making was facilitated through the use of initiation moves. The teachers used initiation moves to get the learners to make meaning of the content by inserting the learners in the concepts, as was the case when Mandy gave information to the learners and used different classrooms that the learners were in to ask whether the two classes were the same population. This incorporation of learners into the lesson not only offered the learners the opportunity to make meaning through situating themselves, but went further to demonstrate that Life Sciences is not just in the textbook, but all around us and experienced daily, including the topic of population ecology (Gilbert, 2001). Such moves were used several times in the teachers' lessons. Another way in which the teachers used initiation moves to facilitate meaning-making was by providing learners with information that they already knew related to the concepts being taught.

This finding supports the argument made by Ausubel (2012) that prior knowledge is an important factor in the meaning-making process of the learners, echoed by Agra et al. (2019), although it is not the only factor. While teaching factors that helped the human population boom, Ntando and Tebogo referred to the medicine that people have access to, to extend their lives. This brought home how the

learners were experiencing those factors in real life, shifting the lesson from abstract to life experience; this signalled meaning-making because the learners interacted with the concepts instead of simply memorising them, as Belouahem (2020) proposed.

The talk moves that the teachers used served different roles in offering learners meaning-making opportunities while learning about population ecology. Initiation moves were used mainly to get the learners to understand simpler concepts such as terms and factors, as suggested by Dizon (2023), which was prevalent in most excerpts of the lessons. The teachers used these initiation moves to get the learners to repeat what they had said (prevalent in Tebogo's lessons), read aloud what was written on the board (prevalent in Mandy's lessons), or give whole definitions on their own (prevalent in Mandy and Ntando's lessons).

Other meaning-making opportunities were facilitated using rejoinders. These rejoinders furthered the classroom talk between the teacher and learners, as suggested by Tytler and Aranda (2015). An example of this is how Ntando and Mandy did not simply mark a learner's answer as incorrect, but asked the learners to elaborate on their answer. By having the learners expand their answers, the teacher was able to identify where the learners went wrong and could redirect them towards making meaning of the concept, as seen in excerpts 3, 7 and 9. By challenging the learners to elaborate, the teachers supported learners to think more critically about their contributions as they supported and argued their points. This echoes what Soysal (2021) found, that challenging moves drive higher-order thinking in learners, leading to internalisation of the concepts being taught, which I argue constitutes meaning-making.

The teachers used rejoinders in a way that invited the learners to contribute if one learner asked a question, facilitating discussion, as shown in excerpts 9 and 10 of Ntando's lessons. The learners would either argue among themselves or work cooperatively to get to the answer, which Rudsberg et al. (2017) and Murphy et al. (2018) highlight as being important to meaning-making. By pivoting the conversation to the rest of the class, the teacher facilitated meaning-making by giving the learners the platform to form their own ideas through cooperation with one another. This cooperation echoes the idea mentioned by Webb and Jones (2009) of a dialogic classroom.

Mandy, after teaching population ecology terminology, told the learners that they would need what they were learning in population ecology for a topic in Grade 12. This gave the learners the incentive to learn the concepts because they serve as a foundation for a grade that most see as the most important grade in school. By making links, the teacher facilitates meaning-making. Scott et al. (2011) argue that pedagogical link-making is a crucial aspect of learning science, and therefore meaning-making. The findings regarding pedagogical link-making support the assertions by Scott et al. (2011) and Staarman and Ametller (2019).

The teachers also challenged learners to think deeply about their ideas, especially in excerpt 4 in Mandy's lesson and excerpt 9 in Ntando's lesson. By doing this, the learners were encouraged to analyse their answers and identify where their contributions were lacking. This finding is in line with Soysal (2021) that challenging learners prompts them to think critically about the contents of the lesson, which leads to meaning-making, according to Haber (2020). This talk move put learners in a position to defend their ideas by adding to them or

discarding them to form new ones, which led to further engagement with the content until the work made sense to them (Webb & Jones, 2009).

The more prevalent ways in which the teachers used talk moves to facilitate meaning-making was to direct the learners to previous experiences and prior knowledge. An example of using prior experience was when Ntando shifted the learners' attention to a storm that had occurred the previous night to explain to them how houses shielded people from those storms (excerpt 10), allowing for their survival. Ntando was using a question that a learner posed to get them to make the connection between real life and the factors that led to the human population boom. Again, this use of a real-life occurrence was a powerful tool because it also helped in the retention of concepts, since the learners were able to relate to the experience.

This finding is supportive of Sarmiento-Campos et al. (2022)'s argument that incorporating real-life experiences in lessons increases the retention of the concept in the learners. Relating the concepts to their experience does not always lead to retention, as argued by Belouahem (2020), but it does make it easier to recall the information in the right context (Ausubel, 1963; Mayer, 2002). Mandy directed the learners to their life experiences when she referred the learners to human populations in different countries, to establish both the definitions of population and species (excerpt 2). This reinforces the socio-cultural theory of learning: that learning is dependent on others' help and prior experience (Sarmiento-Campos et al., 2022; Vygotsky, 1978).

Using the learners' prior knowledge was not limited to that of Life Sciences, but included prior knowledge from other subjects as well, for example, Geography (as was seen in Ntando's lesson), to get the learners to make meaning of the content on how a natural disaster can affect the population. This knowledge from another subject helped solidify concepts that the learners were being taught and those that they already knew (Barnes & Todd, 2021), including those that overlapped in both subjects. In one lesson, Ntando facilitated meaning-making when learners explained to one another density-dependent factors using their knowledge of Geography (excerpt 9). This finding is in line with the assertion made by Saglam et al. (2015) and Ignelzi (2000) that meaning-making is conversational.

The teachers used the different talk moves that they employed to afford learners meaning-making opportunities. These opportunities relied on multiple factors that the teachers were faced with.

5.2.3 Factors that contribute to the teachers' use of talk moves in the classroom to facilitate (or inhibit) meaning-making

Multiple factors contributed to the teachers' use of talk moves. These included wait time, the context of the school, time and Annual Teaching Plan (ATP) constraints. These factors affected the teachers differently as they all have different realities (Mfinanga et al., 2019). The largest contributor was the teachers' cognition. All three teachers had their own values and ideas on how to teach population ecology. As argued by Alzaanin (2019) and Öztürk (2021), the teachers' actions were guided by their beliefs. An example of this is Ntando's use of positive feedback to the learners.

The teachers, especially Ntando and Mandy, gave learners opportunities to answer questions posed to them when they were giving their lessons by giving them enough wait time. Wait time allowed learners to think and reflect on their answers, deepening their thinking and improving their learning as Ingram and Elliott (2016) suggested. This finding is in contrast to the majority of the exchanges in Tebogo's lessons, where learners were not given enough time to think about and answer questions before Tebogo gave them the answer. This lack of wait time prevented the learners from making meaning of the concepts because they were not entrusted with finding the solutions on their own, as An and Childs (2023) suggested. When learners are not allowed to find solutions on their own, their meaning-making process becomes stunted, leaving the learners stuck in the first phase of the meaning-making process, as described by Shuell (1990). This is because by stepping in to provide an answer for the learners, Tebogo reduced the stakes of the question (Mesa & Lande, 2014) and made the learners passive in the learning process (Kranzfelder et al., 2020; Tachie, 2020).

Another inhibitor of meaning-making occurred when the teachers asked routine and rhetorical questions (excerpts 12, 13 and 14), to which the learners parroted back the answers, preventing them from making meaning because with such questions, they cannot critically engage with the content, as argued by Bhattacharya (2022), and end up learning by rote as a result (Grove & Bretz, 2012). Such questions constrain opportunities for the learners, as suggested by Mesa and Lande (2014), because they rely on recitation of isolated facts rather than critical engagement with the concepts being taught, as argued by Lehesvuori et al. (2019).

Using the context of the school environment, all three teachers made attempts to facilitate meaning-making. In excerpt 5, Mandy used the township context of the school to teach population growth curves. At the same time, learners attempted to make meaning using the prevalence of crime in the area and how that affects the population. Ntando used the learners' knowledge of the area and the presence of the homeless to facilitate meaning-making in excerpts 9 and 10, while Tebogo used HIV statistics of the past and present to demonstrate how medical advancements have contributed to the human population boom (excerpt 13). The different contexts led to the teachers having unique opportunities to facilitate meaning-making for their learners by using talk moves that exploited the contexts. This supports the assertion that Mortimer and Scott (2003), and (Howie, 2005), made regarding the role of the school context in meaning-making. However, the school context did not always prove useful in the teacher's lessons and was sometimes detrimental to teaching. This was the case with Mandy, as she lost time due to contextual factors that prevented her from teaching timeously, as she mentioned when asked about why she was rushing through her lessons. This pressure had the effect of limiting how much she could use talk moves to facilitate meaning-making.

The other important factor was the stipulated time in the third term ATP in which to cover the topic of population ecology. Although the ATP, which follows the CAPS document (Department of Basic Education, 2011a) stipulates three weeks (weeks 8 to 10) to teach the topic, this is not feasible because schools close in the eleventh week, making teaching in the last two weeks impractical as tests and exams will be administered at that time. This factor meant that teachers did

not have a lot of time to teach this topic and taught it in a short space of time, which was not the three weeks stipulated in the ATP. This rushing for time meant that teachers could not afford to implement all the lesson ideas that teachers had, as proposed by Coultas (2015) and Melnick and Meister (2008), because they were under pressure to complete the term's ATP, and this showed in the classroom talk, or lack thereof. Time constraints were not only due to the ATP.

Another factor related to this was the prioritisation of Grade 12 over other grades, including Grade 11. This shift in priorities meant that teachers, specifically Tebogo, had to rush through the content as they were instructed to spend more time with the matric learners. This was consistent with a finding by Coultas (2015) that school management sometimes gives directives that interfere with the teacher's plans for their lessons, and this pressure on teachers hinders effective teaching (Teig et al., 2019).

Regarding the teachers' cognition, their main goal was for the learners to gain understanding of the concepts of population ecology. The most prevalent way that they did this was to use the learners' different contributions to direct their teaching, as suggested by Webb and Jones (2009). Because no two classes are ever identical, the teachers used the knowledge of the learners to direct their teaching, seen in excerpts 4, 6, and 9. When they realised that the learners were misunderstanding a concept, the teachers used that as a tool to dictate the talk moves that they used in the lesson to weave interaction in the classroom that led to the learners making meaning of the different concepts of population ecology. This notice was important because Soysal (2021) argues that the teachers ignoring the learners' responses can stunt classroom talk. To achieve this, the

teachers had to be flexible in following semi-structured lessons that are driven by the learners' contribution as much as the teachers' teaching goals.

Ntando emphasised how her tone while using talk moves could be advantageous or detrimental to the meaning-making process of the learners. She valued the learners' state of mind while teaching and took steps to ensure that the learners felt safe and comfortable in their lessons. She also tried to boost the learners' confidence by not using negative feedback, but instead praising and affirming their contributions. This, she said, made the learners feel heard and safe, preventing them from being "turned off" from the topic, which could lead to them not wanting to participate, supporting the argument by Xu et al. (2020) that learner engagement is linked to their emotions. The learners' emotions can therefore lead to them making or not making meaning of the concepts being taught to them. An added benefit to this boost is that the learners felt confident enough that they were offering to answer other learners' questions, furthering classroom talk without putting the burden of directing the lesson solely on the teacher. This engagement was especially prevalent in Ntando's lessons (excerpts 6 to 10).

5.2.4 Addressing the main research question

The teachers used a wide range of talk moves to facilitate meaning-making for their learners by scaffolding the lessons with different talk moves. The different types of initiation and rejoinders invited learners to participate in the classroom talk. The talk moves ranged from simple, closed initiation questions to challenging the learners' contributions to direct them from rote learning where they simply memorised concepts, to internalising the concepts being learnt by making links between them and their prior knowledge and experience (Mayer, 2002; Schuh,

2016), and even knowledge that the learners were yet to gain when Mandy referred to Grade 12 content.

The teachers, with the exception of Tebogo, made strides in making their classrooms dialogic, which Beraldo et al. (2022) argues is fundamental in the meaning-making process. By doing this, the teachers shifted the focal point of the classroom from themselves to the learners, which proved fruitful in the meaning-making process of the learners. Through their talk moves that encouraged learner participation, teachers were able to guide learners to make meaning of the topic of population ecology. This finding supports the assertion by Puntambekar (2022) that through participation, learners can make meaning of concepts. The teachers did not only rely on their own questioning and prompts to facilitate meaning-making, but they also used the learners' questions and contributions as tools to help other learners make meaning of population ecology, which further solidified the teachers' attempts at making their classrooms dialogic.

These meaning-making opportunities were dependent on multiple factors such as the time that was available to the teachers to deliver the content in relation to the stipulated time in the ATP, school context and the external environment that affected school, and therefore teaching time. These factors influenced the teachers' cognition in how they want to conduct their lessons, which supports the argument by Mori (2011) that different factors such as the school context and time influence teacher cognition. This is because the teacher's cognition dictates what is important and what should be ignored in the occurrences of the classroom, and therefore, what concepts are learnt and how.

5.3 Significance of this study

In the broader field of science teaching, in this study, I revealed that meaning-making can be promoted (or inhibited) through talk moves in Life Sciences classrooms. In Chapter 1, Section 1.5, I mentioned that I could not find studies that explore how teachers can promote meaning-making through the use of talk moves. The emergence of talk moves in science classrooms was based on the assumption that they could be used to facilitate interaction, and thus meaning-making (Rudsberg et al., 2017). I have shown in the previous chapters that the focus has always been on how learners make meaning.

Therefore, the findings of the present study contribute to the literature by showing how Life Sciences teachers use talk moves to afford learners meaning-making opportunities. Particularly, the contribution is that through the careful use of specific moves, like those that extend learners' ideas, promoting intersubjectivity as well as leveraging learner prior knowledge can be used to provide learners with opportunities for meaning-making. Furthermore, this study supports the socio-cultural perspective as it shows that meaning-making for learners was accessed through classroom discussions led by teacher talk. It strengthens the argument that meaningful learning is attained by relating current knowledge being taught to the prior knowledge and experience of the learner.

I have also shown how certain moves can inhibit learners' meaning-making, especially through the over-use of negative evaluation, and by closing the interaction pattern too soon through merely providing information to the learners without getting their input. Therefore, the present study shows that IRE/F has lost relevance and is not as effective as using rejoinders in getting learners to actively

think about, and eventually internalise, science concepts and attain conceptual understanding and retention. This attainment happens because the learners are empowered to participate in their own learning. This study emphasises the importance of empowering the learner through talk moves, the opposite of the transmission method of teaching, which this study shows is ineffective at facilitating meaning-making, because there is only one active participant in classroom talk.

Although the use of talk moves to provide opportunities for meaning-making has been revealed in this study, there were several factors that influenced this process. For example, factors such as wait time and teacher cognition seemed to either enable or inhibit learner meaning-making of science concepts. Therefore, another contribution to both research and practice concerns the relevance of these factors. With regard to wait time, this study showed that it is crucial to give learners time to think about and formulate their answers in order to actively engage with the content and eventually make meaning of what is being taught. Teacher cognition played a role in shaping the classroom, such as creating an environment that is conducive. This study showed that creating an environment that allowed learners to make mistakes without fear of being negatively evaluated empowered them to engage in the lesson meaningfully.

Research on the teaching and learning of population ecology has also been neglected over the years, as shown in the literature (Chapter 2). Yet, this is a social topic where learners bring their prior knowledge, including misconceptions, and their experiences (Butler et al., 2015). Because the present study was topic-specific, it highlighted the need to research this neglected topic, especially in light

of the misconceptions that learners showed during the lessons. While I focused on teacher talk moves, this is just one approach that can promote student engagement, and thus meaning-making.

While some factors that influence teachers' use of talk moves were contextual and beyond the teachers' control (for example, time and curriculum), there were some factors that are specific to what happens in the classrooms (for example, not noticing learner contributions and misconceptions). I am of the view that future studies should look into solutions to these factors. These solutions may also come from the perspective of teachers, based on the assumption that teachers are reflective practitioners. This is because, in this study, the teachers were aware of these factors, and therefore may have solutions to some of these factors. Perhaps future studies should look into individual teachers to resolve some of the factors that influence the use of talk moves and learners' meaning-making.

5.4 Limitations of the present study

The present study had multiple limitations, ranging from the sampling to the time constraints pertaining to the study.

The different contexts of the schools gave a glimpse into the nuances of teaching in a rural school as compared to a township and a city school. The research approach used in the present study made the research process easy to replicate and can therefore be used for research focusing on teachers in other districts and provinces, teaching different topics of Life Sciences, or even different grades and subjects.

The use of only audio recordings of the lesson as a data collection method versus video recordings was another limitation because it prevented me from showcasing non-verbal talk from the teachers. However, the advantage of this data gathering method was that it made it easier to guarantee anonymity for the teachers, learners, and school. This shortcoming was overcome by supplementing the audio recordings with field notes during the lessons.

Another limiting factor was the small window of time to gather the data because of the stipulations of the ATP that the topic be taught in the seventh week of the third term. This was exacerbated in part by teachers rushing to complete the topic and teaching it in a few lessons. The time limit also affected the sample size because I could not gather data in the fourth term, as this is not allowed by the Gauteng Department of Education. I overcame this by supplementing my data with SRIs with the teachers to deepen my understanding of their dynamics when teaching population ecology.

The theoretical framework used for this study, the socio-cultural perspective, had its limitations, particularly on teacher agency. The framework did not explicitly account for teachers' cognition, beliefs, and values as factors that influenced how they taught. This necessitated the inclusion of the teacher cognition concept and its role in shaping what occurs in the classroom (Chapter 2, Section 2.9.2). Another limitation of this framework was that it ignored hierarchical structures in the school that affect teacher agency, and by extension, how the teacher taught. I addressed this by mentioning how these power structures affect how teachers conduct their lessons (see Section 2.8 in Chapter 2).

5.5 Implications of the study

In the previous sections, I discussed the main findings of the study and the significance thereof. Below, I offer some implications for professional development of in-service Life Sciences teachers as well as teacher training programmes.

5.5.1 Implications for pre-service teacher development

Although the study focused on experienced teachers, the findings in this study may also be used to think about the structure and contents of Life Sciences teacher training programmes. Life Sciences teacher training programmes should incorporate explicit inclusion of discursive moves as a central component of pedagogy. In other words, methodology modules should focus on equipping pre-service Life Sciences teachers with strategies to facilitate classroom dialogue that promotes meaning-making. Practical approaches like micro-teaching sessions and receiving feedback from the teacher educator and other pre-service teachers can enhance this training.

For example, the focus can be on the role of open-ended questioning; challenging questions and specific approaches on how to elicit learners' responses based on their prior knowledge can be amongst the focus areas of micro-teaching. In addition to practical skills like micro-teaching, teacher training should foster theoretical knowledge of how the use of discursive moves shapes knowledge construction in Life Sciences classrooms. For example, methodology modules should include explicit teaching of the socio-cultural theory of learning, and dialogic teaching frameworks would help teachers understand the epistemic function of discursive moves and factors that can affect this.

5.5.2 Implications for in-service teacher training

In this study, I have shown that the Life Sciences teachers were able to create meaning-making opportunities through the use of specific talk moves. However, there were cases where certain moves could have been used to maximise these opportunities when teaching the topic of population ecology. This is an indication that teachers may not be aware of other moves, when to use them and how to use them depending on the lesson objectives.

Given that the teachers who participated in this study were experienced, there is a need for continuous professional development of in-service Life Sciences teachers based on the new scientific evidence that reveals certain talk moves. For example, it is only recently that research on talk moves revealed different levels of complexity of these moves that can possibly afford learners opportunities to make meaning of science concepts (see Tai and Wei (2021); Zwiers and Crawford (2023)).

Notwithstanding, I acknowledge that different continuing professional development initiatives have existed (see Walton and Engelbrecht (2024); Hennessy et al. (2022)). However, these professional development initiatives seem to have focused on the 'top-down' approach where an academic provides teachers with knowledge and skills on how to facilitate learner engagement to improve learner performance. Although there is evidence that this approach works, there is a need to move to more transformative approaches that allow teachers to engage in collaborative inquiry through the use of models like lesson-study approaches, especially in the South African context (Vermunt et al., 2019).

This approach can include techniques such as eliciting learners' prior knowledge, probing for clarification, and revoicing learner contributions to scaffold deeper understanding. Practical workshops, where teachers engage in the observations of each other's lessons and receive feedback on their use of discursive moves, would enhance their ability to create dialogic platforms for learners to make meaning of science concepts. In this way, teachers can contextually share best practices and co-develop discursive strategies for enhancing meaning-making opportunities in Life Sciences classrooms. This can be done across several topics of Life Sciences, so that teachers can acquire a broader sense of facilitating interactions for learner meaning-making, since each topic presents itself with specific difficulties, like the nature of learner prior knowledge, including misconceptions.

5.6 Future studies

By investigating teachers' use of talk moves to facilitate meaning-making, this study highlighted some areas of possible future research. Below are some recommendations for possible research areas related to this study, for both practice and professional development.

- The focus of this study was limited to the topic of population ecology. By expanding the scope of the study to teachers teaching other Life Sciences topics, as well as other grades and subjects, and in other provinces, a more robust conclusion can be made about the use of talk moves by South African teachers when attempting to offer learners meaning-making opportunities. Those findings can be used to inform policy regarding talk moves implementation in the South African classroom. This would provide

more evidence for how teachers use talk moves to facilitate meaning-making in a variety of contexts.

- The analytical approach used in this study can be extended to other topics such as evolution and human impact on the environment. The topic of evolution (taught in Life Sciences Grade 12), especially the idea of human evolution, is a controversial topic to teach because of learner religious beliefs (Siani et al., 2022), which are accompanied by misconceptions. Using the ATM and TDM frameworks, we can gain an understanding of how teachers approach this topic in a way that addresses misconceptions and guides learners to understanding the topic without alienating them. Another topic that can be studied using the analytical approach in this study is human impact on the environment, particularly climate change, taught in Grade 11 Life Sciences, which overlaps with resources and sustainability taught in Grade 11 Geography. Studying the teaching of these topics using the analytical approach used in this study can give an understanding on how teachers navigate this topic using talk moves to foster meaning-making of these topics, but to also stimulate learner thinking on how responsible stewardship of the environment looks like, which has far-reaching consequences beyond the classroom.
- Owing to a variety of factors, teachers were sometimes unable to maximise meaning-making for learners using their talk moves. An implication of this finding is to investigate how teacher talk moves affect learners' interest in participating in classroom talk, such as how teachers' responses to learner contributions affect the learners' confidence, and how

that influences the dynamics of classroom talk, including the contexts of the classroom and school.

- Another interesting finding in this study, and one that seemed to inhibit teachers' provision of meaning-making opportunities for learners, was the phenomenon of learner contributions going unnoticed by the teachers. This led to unanswered questions and unaddressed misconceptions. Therefore, future studies could look at the influence of 'teacher noticing' on how teachers use discursive moves to facilitate interaction for learner meaning-making.
- While I focused on teacher talk moves, this is just one approach that can promote student engagement, and thus meaning-making. Future studies can, therefore, look at other approaches that can be used to help learners make meaning of population ecology concepts and other Life Sciences concepts. The teachers in this study used pedagogical link-making in their lessons while teaching the topic of population ecology. The idea of pedagogical link-making has also not gained the attention of Life Sciences education researchers, and can be investigated as a method of teaching to engage learners.

5.7 Reflections on inquiry

When I began this study, my goal was to learn how teachers use talk moves to facilitate meaning-making, but I gained more than what I anticipated. I especially found the analysis methods that I used to be interesting as they allowed me to view the findings through the lens of storytelling, something I am passionate

about. The methods allowed me to view each teacher's case as their own story, both seen and unseen, that fit into a much bigger story.

Carrying out this study was a new and challenging experience for me. As an in-service teacher myself, the methods that the teachers used in their classrooms were different from those in my practice. I found myself eager to replicate some of the strategies that the teachers used in my classroom. I found myself invested in the process of teaching and learning population ecology, a seemingly unexciting topic in the subject of Life Sciences. In addition to finding interesting ways to improve my teaching, I was challenged as a novice researcher. I enjoyed researching other researchers in this field and found that their ideas inspired me to continue with this study and add knowledge to the vast amount that is already in existence.

Conducting this study proved challenging in multiple aspects, and there are certain things that I would do differently if I were to conduct it again. The first change would be to not assume that teachers would be eager and willing to participate in the study, and this would have led me to reach out to many more teachers than I originally did. I also wish I had at least one participant from a private school to further enrich the data. I would also ask the teachers their own reflections on having participated in the study. The last thing I would have done differently was to spend less time using analytical approaches that did not work for my study. Although it was frustrating, I did learn a lot about the applications of different analytical approaches, and I believe that has contributed to my growth as a novice researcher.

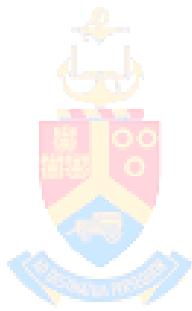
Overall, I found myself growing as both a researcher and a teacher. The knowledge that I have gained during this process has been invaluable, and I find myself with a renewed and growing passion for Life Sciences education and its research.

5.8 Final remarks

By conducting this study, I was able to understand the intricacies of teacher talk moves when teaching population ecology, and how these are affected by multiple factors. This understanding also helped me in identifying how the study can be improved, as well as how other studies can be conducted based on the findings of this study that did not pertain to it directly. Teacher talk, as an integral element of classroom talk, is crucial in the meaning-making process of learners as they engage with a new topic. The teachers used a wide range of talk moves to afford learners meaning-making opportunities while teaching population ecology.

The use of these talk moves reflected the goals that the teachers had for their own classrooms. This study contributes knowledge of talk moves, meaning-making, and population ecology education to the existing literature on these topics. The steps taken in this study, from the selection of participants to the methods of analysis, aided in producing this knowledge. This study has global relevance because it focuses on the teaching and learning of population ecology, a topic taught worldwide in science classrooms. Although this study answered my research questions, it did bring to light other questions regarding meaning-making, classroom talk, teacher noticing, and especially the teaching and learning of population ecology that can potentially open up new lines of inquiry.

The findings of this study can be used in teacher training to improve the quality of teaching and learning of Life Sciences.



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6. REFERENCES

- Acevedo, M. A. (2020). Teaching quantitative ecology online: An evidence-based prescription of best practices. *Ecology and Evolution*, 10(22), 12457-12464.
- Adesope, O. O., & Nesbit, J. C. (2013). Animated and static concept maps enhance learning from spoken narration. *Learning and Instruction*, 27, 1-10.
- Agra, G., Formiga, N. S., Oliveira, P. S. d., Costa, M. M. L., Fernandes, M. d. G. M., & Nóbrega, M. M. L. d. (2019). Analysis of the concept of Meaningful Learning in light of the Ausubel's Theory. *Revista brasileira de enfermagem*, 72, 248-255.
- Ajayi, L. (2008). Meaning-making, multimodal representation, and transformative pedagogy: An exploration of meaning construction instructional practices in an ESL high school classroom. *Journal of Language, Identity, and Education*, 7(3-4), 206-229.
- Alharahsheh, H. H., & Pius, A. (2020). A review of key paradigms: Positivism VS interpretivism. *Global Academic Journal of Humanities and Social Sciences*, 2(3), 39-43.
- Alzaanin, E. I. (2019). An Exploratory Study of the Interplay between EFL Writing Teacher Cognition and Pedagogical Practices in the Palestinian University Context. *Arab World English Journal*, 10(3).
- An, J., & Childs, A. (2023). Teacher Questions, Wait Time, and Student Output in Classroom Interaction in EMI Science Classes: An Interdisciplinary View. *Studies in Second Language Learning and Teaching*, 13(2), 471-493.
- Ausubel, D. P. (1963). The psychology of meaningful verbal learning.
- Ausubel, D. P. (2012). *The acquisition and retention of knowledge: A cognitive view*. Springer Science & Business Media.
- Bakhtin, M. M. (2010). *The dialogic imagination: Four essays*. University of Texas Press.
- Bansal, G. (2018). Teacher discursive moves: Conceptualising a schema of dialogic discourse in science classrooms. *International Journal of Science Education*, 40(15), 1891-1912.
- Barnes, D., & Todd, F. (2021). *Communication and learning revisited: Making meaning through talk*. Routledge.
- Belouahem, Z. (2020). Rote vs meaningful learning in EFL classes: Perspectives and beliefs.
- Beraldo, R., Barbato, S., & Ligorio, M. B. (2022). Dialogic Approach to the Analysis of the Meaning-Making Process in a Blended Setting. *Dialogic Pedagogy*, 10.
- Berryman, A. A. (2020). *Principles of population dynamics and their application*. Garland Science.
- Bhattacharya, U. (2022). "I Am a Parrot": Literacy Ideologies and Rote Learning. *Journal of Literacy Research*, 54(2), 113-136.
- Binu, M. (2020). The role of feedback in classroom instruction. *The Journal of ELTIF*, 5(4), 7-11.
- Birt, L., Scott, S., Cavers, D., Campbell, C., & Walter, F. (2016). Member checking: a tool to enhance trustworthiness or merely a nod to validation? *Qualitative health research*, 26(13), 1802-1811.
- Borg, S. (2003). Teacher cognition in language teaching: A review of research on what language teachers think, know, believe, and do. *Language teaching*, 36(2), 81-109.
- Borg, S. (2013). *Teacher research in language teaching: A critical analysis*. Cambridge University Press.

- Bossér, U., & Lindahl, M. (2021). Teachers' coordination of dialogic and authoritative discourses promoting specific goals in socioscientific issue-based teaching. *International Journal of Science and Mathematics Education*, 19(3), 461-482.
- Boyd, M., & Rubin, D. (2006). How contingent questioning promotes extended student talk: A function of display questions. *Journal of Literacy Research*, 38(2), 141-169.
- Brand, D. (2016). *Shifting the IRF paradigm: an action research approach to improving whole-class interactional questioning competence* [Newcastle University].
- Briscoe, C., & LaMaster, S. U. (1991). Meaningful learning in college biology through concept mapping. *The American Biology Teacher*, 214-219.
- Bruner, J., & Bruner, J. S. (1990). *Acts of meaning: Four lectures on mind and culture* (Vol. 3). Harvard university press.
- Buma, A., & Nyamupangedengu, E. (2020). Investigating teacher talk moves in lessons on basic genetics concepts in a teacher education classroom. *African journal of research in mathematics, Science and Technology Education*, 24(1), 92-104.
- Butler, J., Mooney Simmie, G., & O'Grady, A. (2015). An investigation into the prevalence of ecological misconceptions in upper secondary students and implications for pre-service teacher education. *European Journal of Teacher Education*, 38(3), 300-319.
- Calderhead, J. (1996). Teachers: Beliefs and knowledge.
- Cañas, A. J., & Novak, J. D. (2014). Concept mapping using CmapTools to enhance meaningful learning. In *Knowledge cartography: Software tools and mapping techniques* (pp. 23-45). Springer.
- Cardak, O., & Dikmenli, M. (2016). Student Science Teachers' Ideas about the Degradation of Ecosystems. *International Education Studies*, 9(3), 95-103.
- Carpenter, S. L., Kim, J., Nilsen, K., Irish, T., Bianchini, J. A., & Berkowitz, A. R. (2020). Secondary science teachers' use of discourse moves to work with student ideas in classroom discussions. *International Journal of Science Education*, 42(15), 2513-2533.
- Champe, P. C., Harvey, R. A., & Ferrier, D. R. (2005). *Biochemistry*. Lippincott Williams & Wilkins.
- Chapin, S. H., & Anderson, N. C. (2013). *Classroom discussions in math: A teacher's guide for using talk moves to support the common core and more, grades K-6* (Vol. 6). Math Solutions Sausalito, CA.
- Chen, F., & Abdullah, R. B. (2022). Teacher cognition and practice of educational equity in English as a foreign language teaching. *Frontiers in Psychology*, 13, 820042.
- Chin, C. (2006). Classroom interaction in science: Teacher questioning and feedback to students' responses. *International Journal of Science Education*, 28(11), 1315-1346.
- Chin, C. (2007). Teacher questioning in science classrooms: Approaches that stimulate productive thinking. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, 44(6), 815-843.
- Chiu, M.-H., & Lin, J.-W. (2019). Modeling competence in science education. *Disciplinary and Interdisciplinary Science Education Research*, 1(1), 12.
- Clark, C. M. (1984). *Teachers' thought processes*. Institute for Research on Teaching, Michigan State University.
- Clifton, J. (2006). Facilitator talk. *ELT journal*, 60(2), 142-150.
- Cohen, L., Manion, L., & Morrison, K. (2017). *Research methods in education*. routledge.
- Connelly, L. M. (2016). Trustworthiness in qualitative research. *Medsurg nursing*, 25(6), 435.
- Constitution of the Republic of South Africa*. (1997).

- Cooke, J., Araya, Y., Bacon, K. L., Bagniewska, J. M., Batty, L. C., Bishop, T. R., Burns, M., Charalambous, M., Daversa, D. R., & Dougherty, L. R. (2021). Teaching and learning in ecology: A horizon scan of emerging challenges and solutions. *Oikos*, 130(1), 15-28.
- Correnti, R., Stein, M. K., Smith, M. S., Scherrer, J., McKeown, M., Greeno, J., & Ashley, K. (2015). Improving teaching at scale: Design for the scientific measurement and learning of discourse practice. *Socializing intelligence through academic talk and dialogue*, 303-320.
- Coultas, V. (2015). *Teachers' narratives of classroom talk: what are the challenges?* [UCL Institute of Education].
- Creswell, J. W., & Poth, C. N. (2016). *Qualitative inquiry and research design: Choosing among five approaches*. Sage publications.
- Danielak, B. A., Gupta, A., & Elby, A. (2014). Marginalized identities of sense-makers: Reframing engineering student retention. *Journal of Engineering Education*, 103(1), 8-44.
- Dass, S., & Rinquist, A. (2017). School fees. *Basic education rights handbook: Education rights in South Africa. Johannesburg, South Africa: SECTION27. Available at <http://section27.org.za/wpcontent/uploads/2017/02>*.
- De Bruyn, M. (2014). The protection of personal information (POPI) act: impact on South Africa.
- Denzin, N. K., & Lincoln, Y. S. (2011). *The Sage handbook of qualitative research*. sage.
- Department of Basic Education. (2004). *National Norms and Standards for School Funding*. Pretoria, South Africa: Department of Basic Education
- Department of Basic Education. (2011a). *Curriculum and Assessment Policy Statement Life Sciences*. Gauteng
- Department of Basic Education. (2011b). *Curriculum and Assessment Policy Statement Natural Sciences*.
- Department of Basic Education. (2021c). *National Senior Certificate Diagnostic Report Part 1: Content Subjects*. South Africa: Basic Education
- Department of Basic Education. (2023d). *Diagnostic Report 2023 Book 1*. Gauteng
- Dizon, M. O. (2023). Exploring Teacher Initiation Moves and Communication Attributes in a Homeschool Classroom. *ICALLE 2023*, 623.
- Dochy, F., Segers, M., & Buehl, M. M. (1999). The relation between assessment practices and outcomes of studies: The case of research on prior knowledge. *Review of educational research*, 69(2), 145-186.
- Du Plessis, P., & Mestry, R. (2019). Teachers for rural schools—a challenge for South Africa. *South African Journal of Education*, 39.
- Ergazaki, M., & Ampatzidis, G. (2012). Students' reasoning about the future of disturbed or protected ecosystems & the idea of the 'balance of nature'. *Research in Science Education*, 42, 511-530.
- Evnitskaya, N., & Morton, T. (2011). Knowledge construction, meaning-making and interaction in CLIL science classroom communities of practice. *Language and Education*, 25(2), 109-127.
- Ferreira-Valente, A., Fontes, F., Pais-Ribeiro, J., & Jensen, M. P. (2021). The meaning making model applied to community-dwelling adults with chronic pain. *Journal of Pain Research*, 2295-2311.
- Feryok, A., & Oranje, J. (2015). Adopting a cultural portfolio project in teaching German as a foreign language: Language teacher cognition as a dynamic system. *The Modern Language Journal*, 99(3), 546-564.
- Fiddler, M., & Marienau, C. (2008). Developing habits of reflection for meaningful learning. *New Directions for Adult and Continuing Education*, 118, 75-85.

- Fiorella, L. (2023). Making sense of generative learning. *Educational Psychology Review*, 35(2), 50.
- Fraser, S. (2004). *Doing research with children and young people*. Sage.
- Freire, P. (2000). *The Oppressed*. New York: Herder and Herder.
- Friend, L. (2017). IRE and content area literacies: A critical analysis of classroom discourse. *The Australian Journal of Language and Literacy*, 40(2), 124-134.
- Fusco, E. (2012). *Effective questioning strategies in the classroom: A step-by-step approach to engaged thinking and learning, K-8*. Teachers College Press.
- Galegane, G. (2019). AN INVESTIGATION OF THE DIFFERENT TYPES OF THE INITIATION MOVE. *International E-Journal of Advances in Social Sciences*, 5(14), 979-985.
- Garlick, R. (2013). How price sensitive is primary and secondary school enrollment? Evidence from nationwide tuition fee reforms in South Africa. *Unpublished working paper*. Available at: <http://pubdocs.worldbank.org/en/3241466186067633/garlickschoolfees.pdf>.
- Gay, G. (2018). *Culturally responsive teaching: Theory, research, and practice*. teachers college press.
- Gee, J. P. (2003). Opportunity to learn: A language-based perspective on assessment. *Assessment in Education: Principles, Policy & Practice*, 10(1), 27-46.
- Gibson, D. J., Middleton, B. A., Saunders, G. W., Mathis, M., Weaver, W. T., Neely, J., Rivera, J., & Oyler, M. (1999). Learning ecology by doing ecology: long-term field experiments in succession. *The American Biology Teacher*, 217-222.
- Gilbert, S. F. (2001). Ecological developmental biology: developmental biology meets the real world. *Developmental biology*, 233(1), 1-12.
- Ginting, S. A. (2017). The importance of opening moves in classroom interaction. *Advances in Language and Literary Studies*, 8(6), 7-11.
- Goldkuhl, G. (2012). Pragmatism vs interpretivism in qualitative information systems research. *European journal of information systems*, 21, 135-146.
- Golzar, J., Noor, S., & Tajik, O. (2022). Convenience sampling. *International Journal of Education & Language Studies*, 1(2), 72-77.
- Graham, S., Harris, K. R., Bartlett, B. J., Popadopolou, E., & Santoro, J. (2016). Acceptability of adaptations for struggling writers: A national survey with primary-grade teachers. *Learning Disability Quarterly*, 39(1), 5-16.
- Grapin, S., Haas, A., Goggins, M., Llosa, L., & Lee, O. (2019). Beyond general-purpose talk moves. *Science and Children*, 57(4), 36-43.
- Grove, N. P., & Bretz, S. L. (2012). A continuum of learning: from rote memorization to meaningful learning in organic chemistry. *Chemistry Education Research and Practice*, 13(3), 201-208.
- Grussendorff, S., Booyse, C., & Burroughs, E. (2014). What's in the CAPS package. *A comparative study of the National Curriculum Statement (NCS) and the Curriculum and Assessment Policy Statement (CAPS): FET Phase*.
- Guba, E. (1990). The paradigm dialog. In: sage.
- Guba, E. G. (1981). ERIC/ECTJ annual review paper: Criteria for assessing the trustworthiness of naturalistic inquiries. *Educational communication and technology*, 75-91.
- Gümüşok, F., & Balıkçı, G. (2020). Promoting extended student talk in an EFL classroom. *Eurasian Journal of Applied Linguistics*, 6(2), 205-228.
- Haber, J. (2020). *Critical thinking*. MIT Press.
- Halloun, I. (1996). Schematic modeling for meaningful learning of physics. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, 33(9), 1019-1041.
- Hardman, J. (2019). Analysing student talk moves in whole class teaching. *International Handbook on Dialogic Education*. London: Routledge.

- Hennessey, S., D'Angelo, S., McIntyre, N., Koomar, S., Kreimeia, A., Cao, L., Brugha, M., & Zubairi, A. (2022). Technology use for teacher professional development in low-and middle-income countries: A systematic review. *Computers and Education Open*, 3, 100080.
- Holstermann, N., Grube, D., & Bögeholz, S. (2010). Hands-on activities and their influence on students' interest. *Research in Science Education*, 40, 743-757.
- Hovardas, T., & Korfiatis, K. (2011). Towards a critical re-appraisal of ecology education: Scheduling an educational intervention to revisit the 'balance of nature' metaphor. *Science & Education*, 20, 1039-1053.
- Howe, C., Hennessey, S., Mercer, N., Vrikki, M., & Wheatley, L. (2019). Teacher–student dialogue during classroom teaching: Does it really impact on student outcomes? *Journal of the learning sciences*, 28(4-5), 462-512.
- Howie, S. J. (2005). Contextual factors at the school and classroom level related to pupils' performance in mathematics in South Africa. *Educational research and evaluation*, 11(2), 123-140.
- Hummer, P. J. (1980). Determining the Population Size of Pond Phytoplankton. *American Biology Teacher*, 42(9), 545-548.
- Ignelzi, M. (2000). Meaning-making in the learning and teaching process. *New directions for teaching and learning*, 2000(82), 5-14.
- Ikram, M., & Kenayathulla, H. B. (2022). Out of Touch: Comparing and Contrasting Positivism and Interpretivism in Social Science. *Asian Journal of Research in Education and Social Sciences*, 4(2), 39-49.
- Ingram, J., & Elliott, V. (2016). A critical analysis of the role of wait time in classroom interactions and the effects on student and teacher interactional behaviours. *Cambridge Journal of Education*, 46(1), 37-53.
- İnönü, G. N., & Demircan, H. Ö. (2023). Questioning as an instructional method: Exploring beliefs and reported practices of early childhood educators. *Teaching and Teacher Education*, 135, 104351.
- Jaipal, K. (2010). Meaning making through multiple modalities in a biology classroom: A multimodal semiotics discourse analysis. *Science Education*, 94(1), 48-72.
- Janah, N., Hendayana, S., & Tresnasih, N. (2019). Using transcript-based lesson analysis to determine teacher discourse move in science lesson. *Journal of Physics: Conference Series*,
- Jonassen, D. H., Carr, C., & Hsiu-Ping, Y. (1998). Computers as mindtools for engaging learners in critical thinking. *TECH TRENDS-WASHINGTON DC-*, 43, 24-32.
- Jonassen, D. H., & Strobel, J. (2006). Modeling for meaningful learning. *Engaged learning with emerging technologies*, 1-27.
- Josselson, R., & Hammack, P. L. (2021). *Essentials of narrative analysis*. American Psychological Association.
- Junjie, M., & Yingxin, M. (2022). The Discussions of Positivism and Interpretivism. *Online Submission*, 4(1), 10-14.
- Kamal, S. (2019). Research paradigm and the philosophical foundations of a qualitative study. *PEOPLE: International Journal of Social Sciences*, 4(3), 1386-1394.
- Kang, H. (2017). Preservice teachers' learning to plan intellectually challenging tasks. *Journal of Teacher Education*, 68(1), 55-68.
- Karpicke, J. D. (2012). Retrieval-based learning: Active retrieval promotes meaningful learning. *Current Directions in Psychological Science*, 21(3), 157-163.
- Karpicke, J. D. (2017). Retrieval-Based Learning: A Decade of Progress. *Grantee submission*.
- Karpicke, J. D., & Grimaldi, P. J. (2012). Retrieval-based learning: A perspective for enhancing meaningful learning. *Educational Psychology Review*, 24(3), 401-418.

- Kasworm, C. (2003). Adult meaning making in the undergraduate classroom. *Adult Education Quarterly*, 53(2), 81-98.
- Kelly, G. J. (2013). Discourse in science classrooms. *Handbook of research on science education*, 443-469.
- Khoza, H. C. (2023). Teacher noticing as a driver of interaction patterns in science classrooms. *Journal of Pedagogical Research*, 7(1), 53-66.
- Khoza, H. C. (2024). Leveraging Teacher Educators' Pedagogical Approaches for Biology Terminology Instruction: A South African Case Study. *International Journal of Social Sciences & Educational Studies*, 12(1), 1-18.
- Khoza, H. C., & Maseko, B. (2024). Collaborative Concept Mapping: Investigating the Nature of Discourse Patterns and Features of a Concept Map. *Alberta Journal of Educational Research*, 70(2).
- Khoza, H. C., & Msimanga, A. (2021). Understanding the nature of questioning and teacher talk moves in interactive classrooms: A case of three South African teachers. *Research in Science Education*, 1-18.
- Khoza, H. C. M., N. (In press). Unpacking experienced and novice science teachers' understandings of teacher talk in whole class discussions. *African journal of research in mathematics, Science and Technology Education*.
- Kim, M. (2022). Student agency and teacher authority in inquiry-based classrooms: Cases of elementary teachers' classroom talk. *International Journal of Science and Mathematics Education*, 20(8), 1927-1948.
- Kinchin, I., & Hay, D. (2005). Using concept maps to optimize the composition of collaborative student groups: a pilot study. *Journal of Advanced Nursing*, 51(2), 182-187.
- King, C. J. H. (2010). An analysis of misconceptions in science textbooks: Earth science in England and Wales. *International Journal of Science Education*, 32(5), 565-601.
- Kirk, M., Tytler, R., White, P. J., Ferguson, J. P., & Raphael, J. (2024). Fostering Epistemic Space for Collaborative Solutions in Primary Science Through a Socratic Seminar Inquiry Approach. *Research in Science Education*, 1-22.
- Kivunja, C., & Kuyini, A. B. (2017). Understanding and applying research paradigms in educational contexts. *International Journal of higher education*, 6(5), 26-41.
- Korfiatis, K. J., Stamou, A. G., & Paraskevopoulos, S. (2004). Images of nature in Greek primary school textbooks. *Science Education*, 88(1), 72-89.
- Kostiainen, E., Ukskoski, T., Ruohotie-Lyhty, M., Kauppinen, M., Kainulainen, J., & Mäkinen, T. (2018). Meaningful learning in teacher education. *Teaching and Teacher Education*, 71, 66-77.
- Kottalil, N. K. (2009). Meaning Making and Self-Evaluation. *Online Submission*.
- Kranzfelder, P., Bankers-Fulbright, J. L., García-Ojeda, M. E., Melloy, M., Mohammed, S., & Warfa, A.-R. M. (2020). Undergraduate biology instructors still use mostly teacher-centered discourse even when teaching with active learning strategies. *BioScience*, 70(10), 901-913.
- Kuechle, J. (1995). Ecology: The last word in biology textbooks. *The American Biology Teacher*, 208-210.
- Labov, W. (1972). *Language in the inner city: Studies in the Black English vernacular*. University of Pennsylvania Press.
- Le Grange, L. (2019). Rethinking learner-centred education: Bridging knowledge cultures. *Africa Education Review*, 16(6), 229-245.
- Lee, C., Lee, T., Dickerson, D., Castles, R., & Vos, P. (2021). Comparison of peer-to-peer and virtual simulation rehearsals in eliciting student thinking through number talks. *Contemporary Issues in Technology and Teacher Education*, 21(2), 294-324.

- Lee, T. D., & Glass, B. (2021). Moving talk forward: novice science teachers approximate the practice of leading science discourse. *International Journal of Science Education*, 43(8), 1314-1340.
- Lee, T. D., Lee, C., Newton, M., Vos, P., Gallagher, J., Dickerson, D., & Regenthal, C. (2024). Peer to peer vs. virtual rehearsal simulation rehearsal contexts: Elementary teacher candidates' scientific discourse skills explored. *Journal of Science Teacher Education*, 35(1), 63-84.
- Lehesvuori, S., Hähkiöniemi, M., Viiri, J., Nieminen, P., Jokiranta, K., & Hiltunen, J. (2019). Teacher orchestration of classroom interaction in science: exploring dialogic and authoritative passages in whole-class discussions. *International Journal of Science Education*, 41(17), 2557-2578.
- Li, D., & Zhang, L. (2022). Exploring teacher scaffolding in a CLIL-framed EFL intensive reading class: A classroom discourse analysis approach. *Language teaching research*, 26(3), 333-360.
- Li, L. (2019). *Language teacher cognition: A sociocultural perspective*. Springer.
- Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. sage.
- Litowitz, B. E. (1993). Deconstruction in the zone of proximal development. *Contexts for learning: Sociocultural dynamics in children's development*, 184-196.
- Lombo, N., & Subban, M. (2024). Physical Infrastructure Challenges in Rural Schools: Reflections to Promote Quality Education. *Administratio Publica*, 32(1), 69-101.
- Lucas, T., & Schecter, S. R. (1992). Literacy education and diversity: Toward equity in the teaching of reading and writing. *The Urban Review*, 24(2), 85-104.
- Malcom, C., & Samuel, M. A. (2019). *Learner-centered Science Education* (Vol. 4). Brill.
- Manning, B. H., & Payne, B. D. (1993). A Vygotskian-based theory of teacher cognition: Toward the acquisition of mental reflection and self-regulation. *Teaching and Teacher Education*, 9(4), 361-371.
- Margolis, A. A. (2020). Zone of Proximal Development, Scaffolding and Teaching Practice. *Cultural-Historical Psychology*, 16(3).
- Mashaba, E., & Maile, S. (2013). The cost of teacher absenteeism in selected soshanguve township schools, South Africa. *Int. J. Soc. Sci. Entrep*, 1, 171-197.
- Masinire, A. (2015). Recruiting and retaining teachers in rural schools in South Africa: Insights from a rural teaching experience programme. *Australian and International Journal of Rural Education*, 25(1), 1-13.
- Mayer, R. E. (2002). Rote versus meaningful learning. *Theory into practice*, 41(4), 226-232.
- Melnick, S. A., & Meister, D. G. (2008). A comparison of beginning and experienced teachers' concerns. *Educational Research Quarterly*, 31(3), 39-56.
- Mercer, N., & Littleton, K. (2007). *Dialogue and the development of children's thinking: A sociocultural approach*. Routledge.
- Merriam-Webster Dictionary. (2002). Merriam-webster. On-line at <http://www.mw.com/home.htm>, 8(2), 23.
- Merriam, S. B., & Tisdell, E. J. (2015). *Qualitative research: A guide to design and implementation*. John Wiley & Sons.
- Mesa, V., & Lande, E. (2014). Methodological considerations in the analysis of classroom interaction in community college trigonometry. *Transforming Mathematics Instruction: Multiple Approaches and Practices*, 475-500.
- Mestry, R. (2018). The role of governing bodies in the management of financial resources in South African no-fee public schools. *Educational Management Administration & Leadership*, 46(3), 385-400.
- Mfinanga, F. A., Mrosso, R. M., & Bishibura, S. (2019). Comparing case study and grounded theory as qualitative research approaches. *Focus*, 2(05), 51-56.
- Michaels, S., & O'Connor, C. (2012). *Talk science primer*. Cambridge, MA: TERC.

- Michaels, S., & O'Connor, C. (2015). Conceptualizing talk moves as tools: Professional development approaches for academically productive discussion. *Socializing intelligence through talk and dialogue*, 347-362.
- Mills, S. (2016). Conceptual understanding: A concept analysis. *The Qualitative Report*, 21(3), 546-557.
- Mokgwathi, M. S., Graham, M. A., & De Villiers, J. J. R. (2023). School infrastructure challenges in South Africa: Experiences of high school principals and teachers. *South African Journal of Education*, 43(4).
- Molinari, L., Mameli, C., & Gnisci, A. (2013). A sequential analysis of classroom discourse in Italian primary schools: The many faces of the IRF pattern. *British Journal of Educational Psychology*, 83(3), 414-430.
- Mori, R. (2011). Teacher cognition in corrective feedback in Japan. *System*, 39(4), 451-467.
- Mortimer, E., & Scott, P. (2003). *Meaning Making In Secondary Science Classrooms*. McGraw-Hill Education (UK).
- Mphatsoe, M., & Motseke, M. (2014). Causes of teacher conflict in the township secondary schools-a doctoral report. *Interim: Interdisciplinary Journal*, 13(1), 66-75.
- Mukherji, P., & Albon, D. (2022). Research methods in early childhood: An introductory guide.
- Munson, B. H. (1994). Ecological misconceptions. *The journal of environmental education*, 25(4), 30-34.
- Murphy, P. K., Greene, J. A., Firetto, C. M., Hendrick, B. D., Li, M., Montalbano, C., & Wei, L. (2018). Quality talk: Developing students' discourse to promote high-level comprehension. *American Educational Research Journal*, 55(5), 1113-1160.
- Nevanpää, T., & Law, N. (2006). Pupil's ecological reasoning with help of modeling tool. Proceedings of the 2006 conference on Interaction design and children,
- Novak, J. D. (1990). Concept maps and vee diagrams: Two metacognitive tools for science and mathematics education. *Instructional science*, 19(1), 29-52.
- Novak, J. D. (2002). Meaningful learning: The essential factor for conceptual change in limited or inappropriate propositional hierarchies leading to empowerment of learners. *Science Education*, 86(4), 548-571.
- Novak, J. D., & Gowin, D. B. (1984). *Learning how to learn*. Cambridge University press.
- Nwaeze, E., Onuoha, R., & Ukogo, I. (2016). Innovative teaching methods in science education for junior secondary school basic science students. *Journal of Teacher Perspective*, 11(2), 1-10.
- Öztürk, M. (2021). Teacher cognition: A powerful phenomenon developing and governing habits of teaching. *Turkish Journal of Education*, 10(2), 178-194.
- Park, J., Michaels, S., Affolter, R., & O'Connor, C. (2017). Expanding the conversation: Traditions, research, and practice supporting academically productive classroom talk. In: Oxford research encyclopedia of education.
- Pervin, N., & Mokhtar, M. (2022). The Interpretivist research paradigm: A subjective notion of a social context. *International Journal of Academic Research in Progressive Education and Development*, 11(2), 419-428.
- Pimentel, D. S., & McNeill, K. L. (2013). Conducting talk in secondary science classrooms: Investigating instructional moves and teachers' beliefs. *Science Education*, 97(3), 367-394.
- Polit, D. F., & Beck, C. T. (2010). *Essentials of nursing research: Appraising evidence for nursing practice*. Lippincott Williams & Wilkins.
- Prater, B. L., & Buell, R. R. (1968). A Population Ecology Problem for High School Students. *The American Biology Teacher*, 206-208.

- Puk, T., & Stibbards, A. (2011). Growth in Ecological Concept Development and Conceptual Understanding in Teacher Education: The Discerning Teacher. *International Journal of Environmental and Science Education*, 6(3), 191-211.
- Puntambekar, S. (2022). Distributed scaffolding: Scaffolding students in classroom environments. *Educational Psychology Review*, 34(1), 451-472.
- Rachomas, P., & Trakulkasemsuk, W. (2014). Initiating Talks Used by the Teacher to Stimulate Verbal Responses from Students. *rEFLECTIONS*, 18, 14-30.
- Ragin, C. C., & Amoroso, L. M. (2011). *Constructing social research: The unity and diversity of method*. Pine Forge Press.
- Ramey-Gassert, L. (1998). Beans?? Again?!! The Best \$1.50 Investment for Science Teaching. *Science Activities*, 34(4), 8-13.
- Ramnarain, U. D. (2014). Teachers' perceptions of inquiry-based learning in urban, suburban, township and rural high schools: The context-specificity of science curriculum implementation in South Africa. *Teaching and Teacher Education*, 38, 65-75.
- Reid, N., & Ali, A. A. (2020). *Making sense of learning*. Springer.
- Riazi, A. M. (2016). *The Routledge encyclopedia of research methods in applied linguistics*. Routledge.
- Rogayan Jr, D. V., & Albino, M. M. (2019). Filipino students' common misconceptions in biology: Input for remedial teaching. *Online Science Education Journal*, 4(2), 90-103.
- Romero García, C., Cazorla, M., & Buzón García, O. (2017). Meaningful learning using concept maps as a learning strategy. *JOTSE: Journal of technology and science education*, 7(3), 313-332.
- Rudsberg, K., Östman, L., & Aaro Östman, E. (2017). Students' meaning making in classroom discussions: the importance of peer interaction. *Cultural Studies of Science Education*, 12, 709-738.
- Safdar, M., Hussain, A., Shah, I., & Rifat, Q. (2012). Concept maps: An instructional tool to facilitate meaningful learning. *European Journal of Educational Research*, 1(1), 55-64.
- Saglam, Y. (2022). Dialogic or Authoritative Talk: Which one is more Comprehensible? *International Journal of Scholars in Education*, 5(2), 80-89.
- Saglam, Y., Kanadli, S., Karatepe, V., Gizlenci, E. A., & Goksu, P. (2015). Dialogic Discourse in the Classroom. *International Journal of Education in Mathematics, Science and Technology*, 3(4), 322-335.
- Sakka, W., Nasmilah, N., Khan, A., Mumu, S., & Hamidi, B. (2022). Interplay of teacher talk and learners' motivation in learning English: A Psycholinguistic Study. *Education Research International*, 2022(1), 9099268.
- Sampson, V., & Clark, D. (2009). The impact of collaboration on the outcomes of scientific argumentation. *Science Education*, 93(3), 448-484.
- Sarmiento-Campos, N.-V., Lázaro-Guillermo, J. C., Silvera-Alarcón, E.-N., Cuellar-Quispe, S., Huamán-Romaní, Y.-L., Apaza, O. A., & Sorkkeh, A. (2022). A look at Vygotsky's sociocultural theory (SCT): The effectiveness of scaffolding method on EFL learners' speaking achievement. *Education Research International*, 2022(1), 3514892.
- Schindler, A.-K., Gröschner, A., & Seidel, T. (2018). Teaching science effectively: a case study on student verbal engagement in classroom dialogue.
- Schmidt, H., Heinrich, K. K., Reynolds, J., & Howeth, J. G. (2022). An Ecological Succession Lesson from a Beaver's Point of View. *The American Biology Teacher*, 84(4), 229-235.
- Schreiner, L. A. (2014). Different pathways to thriving among students of color: An untapped opportunity for success. *About Campus*, 19(5), 10-19.
- Schuh, K. L. (2016). *Making meaning by making connections*. Springer.

- Schwichow, M., Zimmerman, C., Croker, S., & Härtig, H. (2016). What students learn from hands-on activities. *Journal of research in science teaching*, 53(7), 980-1002.
- Scott, P. (1998). Teacher talk and meaning making in science classrooms: A Vygotskian analysis and review.
- Scott, P. (2004). Teacher talk and meaning making in science classrooms. *IN: Gilbert, J.(ed) The RoutledgeFalmer Reader in Science Education. London: RoutledgeFalmer*, 74-96.
- Scott, P., & Mortimer, E. (2005). Meaning making in high school science classrooms: A framework for analysing meaning making interactions. *Research and the quality of science education*, 395-406.
- Scott, P., Mortimer, E., & Ametller, J. (2011). Pedagogical link-making: a fundamental aspect of teaching and learning scientific conceptual knowledge. *Studies in Science Education*, 47(1), 3-36.
- Scott, P. H., Mortimer, E. F., & Aguiar, O. G. (2006). The tension between authoritative and dialogic discourse: A fundamental characteristic of meaning making interactions in high school science lessons. *Science Education*, 90(4), 605-631.
- Sedláček, M., & Šedřova, K. (2020). Are student engagement and peer relationships connected to student participation in classroom talk? *Learning, culture and social interaction*, 26, 100411.
- Seker, H. (2004). *The effect of using the history of science in science lessons on meaningful learning* [The Ohio State University].
- Shavelson, R. J., & Stern, P. (1981). Research on teachers' pedagogical thoughts, judgments, decisions, and behavior. *Review of educational research*, 51(4), 455-498.
- Shenton, A. K. (2004). Strategies for ensuring trustworthiness in qualitative research projects. *Education for information*, 22(2), 63-75.
- Shuell, T. J. (1990). Phases of meaningful learning. *Review of educational research*, 60(4), 3.
- Siani, M., Stahi-Hitin, R., & Yarden, A. (2022). Student opposition to learning evolution and how teachers deal with this following a teacher training course. *Journal of Science Teacher Education*, 33(7), 764-785.
- Smart, J. B., & Marshall, J. C. (2013). Interactions between classroom discourse, teacher questioning, and student cognitive engagement in middle school science. *Journal of Science Teacher Education*, 24(2), 249-267.
- Smith, B. (2016). Narrative analysis. *Analysing qualitative data in psychology*, 2, 202-221.
- Soysal, Y. (2021). Talking science: Argument-based inquiry, teachers' talk moves, and students' critical thinking in the classroom. *Science & Education*, 30(1), 33-65.
- Soysal, Y., & Yilmaz-Tuzun, O. (2021). Relationships between teacher discursive moves and middle school students' cognitive contributions to science concepts. *Research in Science Education*, 51, 325-367.
- Staarman, J. K., & Ametller, J. (2019). Pedagogical link-making with digital technology in science classrooms: new perspectives on connected learning. In *The Routledge international handbook of research on dialogic education* (pp. 497-508). Routledge.
- Strat, T. T. S., Henriksen, E. K., & Jegstad, K. M. (2024). Inquiry-based science education in science teacher education: a systematic review. *Studies in Science Education*, 60(2), 191-249.
- Studhalter, U. T., Leuchter, M., Tettenborn, A., Elmer, A., Edelsbrunner, P. A., & Saalbach, H. (2021). Early science learning: The effects of teacher talk. *Learning and Instruction*, 71, 101371.

- Sulistiyowardani, M., Mambu, J. E., & Pattiwael, A. S. (2020). Indonesian EFL teachers' cognitions and practices related to social justice. *Indonesian Journal of Applied Linguistics*, 10(2), 420-433.
- Suryani, A. (2008). Comparing case study and ethnography as qualitative research approaches. *Jurnal Ilmu Komunikasi*, 5(1).
- Suwiknyo, T. (2023). *Question to promote meaningful learning: a case at limbangan senior high school* UNIVERSITAS ISLAM NEGERI].
- Tachie, S. A. (2020). The challenges of south african teachers in teaching euclidean geometry. *International Journal of Learning, Teaching and Educational Research*, 19(8), 297-312.
- Tai, K. W., & Wei, L. (2021). Constructing playful talk through translanguaging in English medium instruction mathematics classrooms. *Applied Linguistics*, 42(4), 607-640.
- Teig, N., Scherer, R., & Nilsen, T. (2019). I know I can, but do I have the time? The role of teachers' self-efficacy and perceived time constraints in implementing cognitive-activation strategies in science. *Frontiers in Psychology*, 10, 1697.
- ter Borg, R. J. (2022). Adapting Science Teaching Explanations to Secondary School Learners.
- Torlaklı, B. (2019). Vocabulary Teaching: From Rote Learning to Meaningful Learning. *Energizing Teacher Research*, 171.
- Tytler, R., & Aranda, G. (2015). Expert teachers' discursive moves in science classroom interactive talk. *International Journal of Science and Mathematics Education*, 13, 425-446.
- Vallori, A. B. (2014). Meaningful learning in practice. *Journal of education and human development*, 3(4), 199-209.
- Van den Heuvel, M., Demerouti, E., Bakker, A. B., & Schaufeli, W. B. (2013). Adapting to change: The value of change information and meaning-making. *Journal of Vocational Behavior*, 83(1), 11-21.
- van der Veen, C., Dobber, M., & van Oers, B. (2018). Engaging children in dialogic classroom talk: Does it contribute to a dialogical self? *The dialogical self theory in education: A multicultural perspective*, 49-63.
- van der Westhuizen, C. P., & Golightly, A. (2018). Global Understanding in South Africa. *Geography education for global understanding*, 173-181.
- Van Maanen, J. (1979). Reclaiming qualitative methods for organizational research: A preface. *Administrative science quarterly*, 24(4), 520-526.
- Vermunt, J. D., Vrikki, M., van Halem, N., Warwick, P., & Mercer, N. (2019). The impact of Lesson Study professional development on the quality of teacher learning. *Teaching and Teacher Education*, 81, 61-73.
- Vygotsky, L. (1935). The development of everyday and scientific concepts at school age. *Umstvennoe razvitie detei v protsesse obucheniya*, 96-115.
- Vygotsky, L. S. (1978). *Mind in society: Development of higher psychological processes*. Harvard university press.
- Wallace, R. L. (2005). Teaching Population Growth Using Cultures of Vinegar Eels. *Bioscene: Journal of College Biology Teaching*, 31(1), 21-25.
- Walton, E., & Engelbrecht, P. (2024). Inclusive education in South Africa: Path dependencies and emergences. *International Journal of Inclusive Education*, 28(10), 2138-2156.
- Wang, B., & Ma, Y. (2019). Authoritative classroom discourse: The abuse of power in a Chinese classroom. In *The Routledge Handbook of Chinese Discourse Analysis* (pp. 364-376). Routledge.
- Waring, H. Z. (2009). Moving out of IRF (Initiation-Response-Feedback): A single case analysis. *Language Learning*, 59(4), 796-824.

- Webb, M., & Jones, J. (2009). Exploring tensions in developing assessment for learning. *Assessment in Education: Principles, Policy & Practice*, 16(2), 165-184.
- Wei, L., Murphy, P. K., & Firetto, C. M. (2018). How can teachers facilitate productive small-group talk? An integrated taxonomy of teacher discourse moves. *The Elementary School Journal*, 118(4), 578-609.
- Wertsch, J. V. (1991). A sociocultural approach to socially shared cognition.
- Whiteley, A. R., Woolf, J., Kennedy, K., Oberbillig, D., & Brewer, C. (2007). Classroom mark-recapture with crickets. *The American Biology Teacher*, 69(5), 292-297.
- Wilmes, S. E., & Siry, C. (2021). Multimodal Interaction Analysis: A Powerful Tool for Examining Plurilingual Students' Engagement in Science Practices: Proposed Contribution to RISE Special Issue: Analyzing Science Classroom Discourse. *Research in Science Education*, 51(1), 71-91.
- Winstead, L. (2004). Increasing academic motivation and cognition in reading, writing, and mathematics: Meaning-making strategies. *Educational Research Quarterly*, 28(2), 29-47.
- Wong, K. P. (2015). Facilitating a meaningful learning experience for students by multimedia teaching approach. *Asia Pacific Journal of contemporary education and communication technology*, 1(1), 72-80.
- Wood, T. (1994). Patterns of interaction and the culture of mathematics classrooms. In *Cultural perspectives on the mathematics classroom* (pp. 149-168). Springer.
- Xu, B., Chen, N.-S., & Chen, G. (2020). Effects of teacher role on student engagement in WeChat-Based online discussion learning. *Computers & Education*, 157, 103956.
- Yilmaz, K. (2013). Comparison of quantitative and qualitative research traditions: Epistemological, theoretical, and methodological differences. *European journal of education*, 48(2), 311-325.
- Yin, R. K. (2009). *Case study research: Design and methods* (Vol. 5). sage.
- Zhang, Z., & Lamb, M. (2024). Teachers' questioning practices in Chinese secondary biology classrooms. *International Journal of Science and Mathematics Education*, 1-26.
- Zittoun, T., & Brinkmann, S. (2012). Learning as meaning making. *Encyclopedia of the Sciences of Learning*, 1809-1811.
- Zwiers, J., & Crawford, M. (2023). *Academic conversations: Classroom talk that fosters critical thinking and content understandings*. Routledge.

APPENDICES

Appendix A: University ethics approval letter



FACULTY OF EDUCATION
Ethics Committee

Amendment

31 July 2023

Dear Miss N Nkomo

The application for ethical clearance for the research project described below served before this committee on 19 July 2023 :

Ethics Protocol No:	EDU096/23 KHOZA 23-02
Principal investigator:	Miss N Nkomo
Student/Staff No:	14196388
Degree:	Masters
Supervisor/Promoter:	Dr C Khoza
Department:	Science Mathematics and Technology Education

The decision by the committee is reflected below:

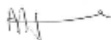
Decision:	Approved
Comments:	
Period of approval:	Two years

The approval by the Ethics Committee is subject to the following conditions being met:

1. The research will be conducted as stipulated on the application form submitted to the Ethics Committee with the supporting documents.
2. Proof of how you adhered to the Department of Basic Education (DBE) policy for research must be submitted where relevant.
3. In the event that the research protocol changed for whatever reason the Ethics Committee must be notified thereof by submitting an amendment to the application, together with all the supporting documentation that will be used for data collection namely; questionnaires, interview schedules and observation schedules, for further approval before data can be collected. The changes may include the following but are not limited to:
 - Change of investigator,
 - Research methods any other aspect therefore and,
 - Participants.

The Ethics Committee of the Faculty of Education does not accept any liability for research misconduct, of whatsoever nature, committed by the researcher(s) in the implementation of the approved protocol.

Best wishes



Prof Funke Omidire
Chair: Ethics Committee
Faculty of Education

Room 3-83, Level 3, Aldoei Building
University of Pretoria, Private Bag X20
Hatfield 0026, South Africa
Tel +27 (0)12 420 5856
Email edu.ethicsadmin@up.ac.za
www.up.ac.za

Faculty of Education
Fakulteit Opvoedkunde
Lefapha la Thuto

Appendix B: Gauteng Department of Education approval letter



GAUTENG PROVINCE

Department: Education
REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

GDE RESEARCH APPROVAL LETTER

Date:	08 August 2023
Validity of Research Approval:	08 February 2023– 30 September 2023 2023/320
Name of Researcher:	Nkomo N.
Address of Researcher:	631 Lievaart Street Philip Nel Park/Pretoria
Telephone Number:	0789586870
Email address:	U14196388@tuks.co.z
Research Topic:	Life Sciences teachers' use of talk moves that afford learners with meaning-making opportunities
Name of University:	University of Pretoria
Type of qualification	Masters
Number and type of schools:	10 Secondary Schools
District/s/HO	Tshwane North, Tshwane West

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

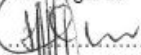
Callie w 08/08/2023

The following conditions apply to GDE research. The researcher may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:

1. Letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.
2. The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.
3. **Because of the relaxation of COVID 19 regulations researchers can collect data online, telephonically, physically access schools or may make arrangements for Zoom with the school Principal. Requests for such arrangements should be submitted to the GDE Education Research and Knowledge Management directorate.**
4. **The Researchers are advised to wear a mask at all times, Social distance at all times, Provide a vaccination certificate or negative COVID-19 test, not older than 72 hours, and Sanitise frequently.**
5. A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s have been granted permission from the Gauteng Department of Education to conduct the research study.
6. A letter / document that outline the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.
7. The Researcher will make every effort obtain the goodwill and co-operation of all the GDE officials, principals, and chairpersons of the SGBs, teachers and learners involved. Persons who offer their co-operation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.
8. Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal (if at a school) and/or Director (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.
9. Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year. If incomplete, an amended Research Approval letter may be requested to conduct research in the following year.
10. Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.
11. It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.
12. The researcher is responsible for supplying and utilising his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.
13. The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations.
14. On completion of the study the researcher/s must supply the Director: Knowledge Management & Research with one Hard Cover bound and an electronic copy of the research.
15. The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned.
16. Should the researcher have been involved with research at a school and/or a district/head office level, the Director concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards



Dr. Gumani Mukatuni
Acting CES: Education Research and Knowledge Management

DATE: 08/08/2023

2

Making education a societal priority

Office of the Director: Education Research and Knowledge Management

7th Floor, 17 Simmonds Street, Johannesburg, 2001

Tel: (011) 355 0488

Email: Faith.Tshabalala@gauteng.gov.za

Website: www.education.gpg.gov.za

Appendix C: Consent letter to principals

LETTER OF INFORMED CONSENT: PRINCIPAL

Groenkloof Campus

Pretoria

0002

August 2023

Dear Principal

I am a Masters's student studying at the University of Pretoria in South Africa, Faculty of Education, conducting a research project titled, *Life Sciences teachers' use of talk moves that afford learners with meaning-making opportunities*. In the current study, I intend to explore the Life Sciences teachers' discourse moves employed in the classrooms when teaching about the topic of population ecology that is taught in Grade 11 in the third term, in Gauteng province.

I would like to collect data at several schools in Gauteng in the Tshwane West and Tshwane North districts, including your school, for this project. Thus, I humbly request your permission to also conduct my research at your school. Findings from the current study will help equip Life Sciences teachers with skills that will develop their teaching strategies when teaching about population ecology. The upper structures will also benefit from this current study as well as the Department of Education.

I am seeking your authorisation to interview one of your school's Grade 11 Life Sciences teachers in person. The interview schedule has 14 questions, and the interview will last about 45 minutes after school hours. The interviews will be audio-recorded. The recordings obtained from the interviews will be used for transcription and analysis of data. Data obtained from this study will be interpreted for identifying themes and codes, this will ensure the credibility of the study, necessary for quality assurance in a research study.

This study also involves taking video recordings when the topic of population ecology is taught. However, this research will not comment on the teachers' competencies as Life Sciences teachers. Observations will last for two weeks and be persistent to ensure the dependability and credibility of the study. Final findings will be sent to you on request, but no individual identifying information such as the name of the school, will be released to you or any other interested parties. Transcripts obtained from the recordings will be treated with confidentiality, only the supervisor, myself, and the transcriber will have access to the recordings and transcripts. The transcriber will sign a confidentiality agreement.

The information provided by teachers will be used for academic purposes only and may be published in scientific journals. A summary of the findings will be made available on request. I also request permission to use data obtained from the current study confidentially and anonymously, for further research purposes, as the data sets are the intellectual property of the University of Pretoria. The confidentiality and privacy applicable to this study will be binding on further research studies.

There will be no tuition time lost, no teaching activities interrupted, and no incentives of any sort will be awarded to the participants to avoid bias and promote voluntary participation. There will also be no implication for academic assessments for participation or non-participation.

Only I as a researcher and my supervisors will know the names of the schools and the teachers, these names will be treated with confidentiality and will not be disclosed. Pseudonyms will be used in spoken and written reports. All participating individuals will be asked to sign a consent/assent letter, and all participation in the current research project would be voluntary. No deception or manipulation will be employed in any element of the research process.

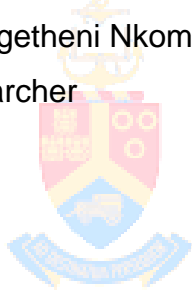
The Ethics Committee of the Faculty of Education at the University of Pretoria has approved this study. The recordings and all the data collected will be stored at the Faculty of Education at the University of Pretoria for a minimum of 10 years, as per the rules and regulations of the Ethics Committee of the University. Electronic data will be stored on a password-protected flash drive.

Although all participation in the research will be voluntary, the participation of the schools in Tshwane West and Tshwane North is very important for the success of this research project. I would highly appreciate the completion of the accompanying consent letter if you agree to grant the research permission. Should there be any further inquiries, you are more than welcome to contact me or my supervisors.

Yours sincerely,

Ms. Ngetheni Nkomo

Researcher



UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

DECLARATION OF CONSENT

Signing on this page means that you grant permission for your school to participate in the research project and that you are aware of the intended research process.

I, _____(name and surname), the principal of _____ (name of the school), hereby give consent for my school to participate in the study and declare that I understand the procedures described above and that my questions about this study have been answered.

Signature of the principal

Date



UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Appendix D: Consent letter to teachers

LETTER OF INFORMED CONSENT: TEACHERS

Groenkloof Campus

Pretoria

002

August 2023

Dear Teacher

LETTER OF INFORMED CONSENT: TEACHERS

I am a Masters's student studying at the University of Pretoria in South Africa, Faculty of Education, conducting a research project titled, *Life Sciences teachers' use of talk moves that afford learners with meaning-making opportunities*. In the current study, I intend to explore the Life Sciences teachers' talk moves employed in the classrooms when teaching about the topic of population ecology which is taught in Grade 11 by Life Sciences teachers, third term, in Gauteng province. Discourse moves in this case mean the kind of questions the teacher asks and the responses the teacher gives to learner contributions.

I would like to collect data from several schools in Gauteng province, in the Tshwane West and Tshwane North districts, including your school for the research project. I, therefore, humbly seek your permission to observe the kind of moves discourse moves you are using when teaching the topic of population ecology to Grade 11 Life Sciences learners. The lessons will be video-recorded, and audio recorded. This will be necessary to transcribe data for analysis purposes. The findings of the current study will not in any way comment on your competencies as a Life Sciences teacher. Prolonged observation, which will take two weeks, will enable me to ensure dependability, which is a quality assurance measure necessary for the research study. The final findings of this study will be sent to you or your principal on request, however, no individual identifying information will be released to you, your principal, or any other interested parties. The findings of this study will help teacher development in facilitating interactions by asking certain types of questions and responding to learners' contributions in

a certain way when teaching about population ecology. The upper structures in the Department of Education will also benefit in structuring the content and developing Life Sciences teachers through this study.

I also request your participation in an interview. The interview schedule has 14 questions and will last for 45 minutes at most. The interview will not be conducted during school hours, at a time that will be convenient for you. The interview will be audio-recorded, to transcribe and analyse the data obtained. The recordings and transcripts obtained will be treated with confidentiality, only my supervisors, the transcriber, and myself will have access to the recordings and transcripts. The transcriber will sign a confidentiality agreement. The information you provide will only be used for academic purposes, and thus, may be published in scientific journals.

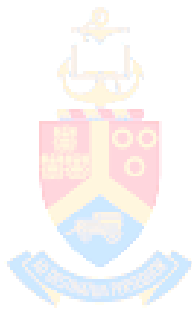
Teaching time will not be lost, the normal teaching activities will not be interrupted, and no incentives/ compensations will be given to participants to avoid bias and promote voluntary participation. There will also be no implication for academic assessments for participation or non-participation.

Only I as a researcher and my supervisors will know the names of the schools and the teachers, these names will be treated with confidentiality and will not be disclosed. Pseudonyms will be used in spoken and written reports. All participating individuals will be asked to sign a consent/ assent letter, and all participation in the current research project would be voluntary. No deception or manipulation will be employed in any element of the research process.

The Ethics Committee of the Faculty of Education at the University of Pretoria has approved this study. The recordings and all the data collected will be stored at the Faculty of Education at the University of Pretoria for a minimum of 10 years, as per the rules and regulations of the Ethics Committee of the University. Electronic data will be stored on a password-protected flash drive.

Although all participation in the research will be voluntary, the participation of the schools in the Tshwane West and Tshwane North districts is very important for the success of this research project. I would highly appreciate the completion of the accompanying consent letter if you agree to grant me permission to conduct this research in your classroom. Should there be any further inquiries, you are more than welcome to contact me or my supervisors.

Yours sincerely,
Ms. Ngetheni Nkomo
Researcher



UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

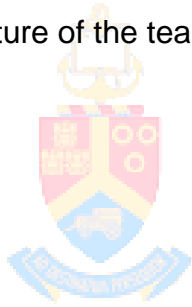
DECLARATION OF CONSENT

Signing on this page means that you grant permission for your school to participate in the research project and that you are aware of the intended research process.

I, _____(name and surname), Life Sciences teacher at _____ (name of the school), hereby give consent to participate in the study and declare that I understand the procedures described above and that my questions about this study have been answered.

Signature of the teacher

Date



UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Appendix E: Consent letter to learners

LETTER OF INFORMED ASSENT: LEARNERS

Groenkloof Campus
Pretoria
0002
August 2023

Dear Learner

LETTER OF INFORMED ASSENT: LEARNERS

Why am I here?

I am a Masters' student studying at the University of Pretoria in South Africa, Faculty of Education, conducting a research project titled, *Life Sciences teachers' use of talk moves that afford learners with meaning-making opportunities*. In the current study, I intend to explore how your teachers ask questions and respond to learners' contributions when teaching about the topic of population ecology, which is taught in Grade 11 in the third term, in Gauteng province. In this study, I will be using video recordings taken in class to observe teachers' talk moves and the learners' responses, and how these contribute to learners being able to understand population ecology. This study will provide an understanding of how teachers use classroom talk when teaching population ecology to facilitate learners in making meaning of the topic. I would like to invite you to be a part of this study.

What will my involvement be?

Firstly, during your normal Life Sciences periods, video recordings will be taken of the teaching and learning of the topic population ecology in Life Sciences Grade 11 classrooms. The video recording of the lessons will occur for two consecutive weeks, and only the teacher will be in the classroom with you. Your Life Sciences teacher will teach you about population ecology and ask some questions where necessary and provide feedback. These video recordings will be taken so that I can access the data at a later stage to transcribe. I will use the recordings to analyse the talk moves the Life Sciences teachers use and the

learners' responses during the teaching and learning of the topic of population ecology.

The name of the school, teachers, and your name will be treated with confidentiality and will not be disclosed. Instead, I will use pseudonyms for the schools, teachers, and learners in spoken and written reports. The recordings obtained from the observations will be treated with confidentiality. Only my supervisors, myself, and the transcriber will have access to the recordings and transcribed data. The transcriber will sign a confidentiality agreement. Thus, there is no need for you to be concerned about what anyone will think about what you said in class. Note that the information you provide will be used for academic purposes only and may also be published in academic journals.

Additionally, it is also important to note that no teaching time will be lost, the normal teaching activities will not be interrupted, and no incentives/compensation will be provided to the participants to avoid bias and promote voluntary participation. There will be no implication for academic assessments for participation or non-participation. There will also be no deception at any point in the study.

Will the project help me?

The findings of this research project might help improve your learning skills in Life Sciences, for the population ecology topic. This might not improve your learning skills instantly; however, it may be for future purposes in Life Sciences lessons.

What if I have any questions?

Questions in relation to this project can be directed to your Life Sciences teacher. If you have any questions later or after school hours, you are more than welcome to contact me (Ngetheni Nkomo) via text message or phone call at 0789586870 or ask to see me at your school.

Do my parents/ guardians know about this project?

The project was explained to parents/guardians in a letter, and they agreed that you could be part of the project if you want to. You are allowed to discuss this with your parent/ guardian before deciding if you are going to be part of the project or not.

What will happen to the data collected?

The Ethics Committee of the Faculty of Education at the University of Pretoria has approved this study. The data collected and all the recordings will be stored for 10 years at the Faculty of Education at the University of Pretoria as per the rules and regulations of the University of Pretoria. Electronic data will be stored on a password-protected flash drive.

Do I have to be involved in this project?

Although your participation in this project is completely voluntary, your participation is very important. However, if you are not interested in participating in the research, do not give your assent to participate, and should your parent not give consent for your participation, you will be excluded from the research study. This means that none of your responses to the Life Sciences teacher will be used in this study.

If you are willing to participate in this study, kindly sign the accompanying declaration of assent.

Yours sincerely,

Ms. Ngetheni Nkomo

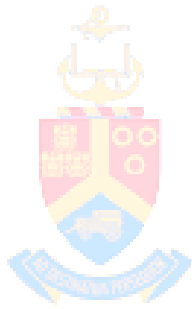
DECLARATION OF ASSENT

Signing on this page means that you agree to participate in the research project and know what will happen when we do the project. If you decide to withdraw from the project at any given time, you must inform the Life Sciences teacher or me.

I, _____ (name and surname), hereby assent to participate in the study and declare that I understand the procedure described above and that my questions have been answered.

Signature of the learner

Date



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Appendix F: Consent letter to parents

LETTER OF INFORMED CONSENT: PARENT

Groenkloof Campus

Pretoria

0002

August 2023

Dear Parent/ Guardian

I am a Masters' student studying at the University of Pretoria in South Africa, Faculty of Education, conducting a research project titled, Life Sciences teachers' use of talk moves that afford learners with meaning-making opportunities. In the current study, I intend to explore the Life Sciences teachers' talk moves employed in the classrooms when teaching about the topic population ecology which is taught in Grade 11, third term, in Gauteng province. In this study, I will be observing the teachers' talk moves and how these help learners in making meaning of the topic of population ecology. I would like to respectfully ask your permission for your child to participate in this research project. Thus, I would like to provide you with more information about this project.

What will the involvement of your child in this research project be?

Firstly, I will observe Life Sciences teachers and learners during the teaching and learning of the topic of population ecology in Grade 11. The lessons will take place during normal school hours in the normal Life Sciences classroom. The teachers will be teaching about the topic of population ecology, ask the learners questions, and where necessary provide feedback. This may lead to your child responding to certain questions and giving their own input as the topic of population ecology is being taught.

The lessons will be video recorded so that I can have access to the data for transcribing and analysis at a later stage. The name of the school, teachers, and learners that participate in this study will be treated with confidentiality and will

not be disclosed. Instead, I will use pseudonyms for the schools, teachers, and learners in spoken and written reports. Therefore, there is no need to be concerned about what others may think about your child's responses in class. The recordings will be treated confidentially. Only my supervisors, myself, and the transcriber will have access to the recordings and transcripts. The transcriber will sign a confidentiality agreement.

Additionally, it is also important to note that no tuition time will be lost, the normal teaching activities will not be interrupted, and no incentives/ compensation will be provided to the participants to avoid bias and to promote voluntary participation. There will also be no implication for academic assessments for participation or non-participation. The learners will not be exposed to deception at any point in the study.

Finally, I would like to ask your permission to use your child's answers, confidentially and anonymously, for further research purposes to help other learners in their studies, as data sets are the intellectual property of the University of Pretoria, and where relevant, project funders. The confidentiality and privacy applicable to this study will be binding on future studies. Note that the information you provide will be used for academic purposes only and may also be published in academic journals.

Will the project help your child?

The findings of this research project might help improve your child's learning skills in Life Sciences, of the population ecology topic. This improvement will not be instant; however, it may be for future purposes in Life Sciences lessons.

What if you have any questions?

Questions in relation to this project can be directed to your child's Life Sciences teacher. If you have any questions later or after school hours, you are more than

welcome to contact me (Ngetheni Nkomo) via text message or phone call at 0789586870 or ask to see me at your school or even ask my supervisors using the contact details provided below.

Does your child know about this project?

The project will be explained to your child in a letter, and they will be informed that your consent will be signed first before the child can agree to be part of the project if they want to. You are allowed to discuss this with your child before deciding if they want to be part of the project or not.

What will happen to the data collected?

The Ethics Committee of the Faculty of Education at the University of Pretoria has approved this study. The data collected and all the recordings will be stored for 10 years at the Faculty of Education at the University of Pretoria as per the rules and regulations of the University of Pretoria. Electronic data will be stored on a password-protected flash drive.

Does your child have to be in the project?

Participation of your child in this project is completely voluntary. If your child is not interested in participating in the research do not give your consent to participate, and should you not give consent for your child's participation, your child will be excluded from the research study. This means that none of your child's responses to the Life Sciences teacher will be used in this study.

If you are willing to grant your child permission to participate in this study, kindly complete and sign the accompanying declaration of consent letter.

Yours sincerely,

Ms. Ngetheni Nkomo

DECLARATION OF CONSENT

Signing on this page means that you give permission for your child to participate in the research project and you understand what will happen during the project. If you decide to withdraw your child from the project at any given time, you must inform the Life Sciences teacher or myself.

I, _____ (name and surname), the
parent of _____ (your child's name and
surname) hereby give consent for my child to participate in the study and declare
that I understand the procedures described above and that my questions have
been answered.

Signature of the parent/ guardian

Date



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Appendix G: Field notes

Field notes.
Teacher 1: Mandy
12. September 2023

Mandy: A population is...
She writes down the definition on the board while learners read it off.
Mandy underlines same species, same area, same time while emphasising them as she repeats the definition.

Mandy asks the learners if the class they are in and the one next door are the same population but learners misinterpret the question so Mandy emphasises "this class" and 'the next class' as she asks the question again.
Learner give conflicting ~~tea~~ answers so Mandy picks a learner who raises his hand

The learner explains the answer but ~~the~~ is still wrong so Mandy repeats the incorrect answer to the rest of the class, which leads to the learners arguing again. Mandy then calls them to order.
Mandy ~~says~~ asks the question again and challenges the learners but they still get it wrong so Mandy demonstrates how the two classes are different populations and the learners repeat the definition.
Mandy then moves on to define ecology and other terms. She stresses the importance of knowing the terminology since they will need it in Grade 12,
Mandy asks the learners what they think a species is