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Exploring pedagogical link-making and teacher talk moves in Grade 10 Life Sciences classrooms

by

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Co-supervisor: Prof. J. J. R. de Villiers

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Declaration

I declare that the dissertation, which I hereby submit for the degree Magister Educationis in November 2024 at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

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Abstract

Pedagogical link-making (PLM) is essential in the alleviation of knowledge compartmentalisation caused by the teaching of science as discrete concepts. This process is achieved by means of classroom talk. Grounded within the broader sociocultural theory, this qualitative multiple case study explored how three Life Sciences teachers utilised teacher talk moves (TTMs) to promote pedagogical links in their Grade 10 classrooms and factors that influence the use of these moves. Data were collected through interviews and Video data (video-data). The transcripts from video data were analysed by means of this study's introduced PLM-TTM conceptual framework. To analyse the interviews whose schedules were informed by the Video data analyses both narrative analysis and analysis of narratives approaches were used. This study revealed that knowledge building pedagogical links and provides information teacher talk moves were dominant in the classrooms and this was attributed to the influential factor of the Nature of the Subject, along with the nature of the topics taught in those lessons. Teaching experience was found to be detrimental to the instructional practice of Life Sciences teachers, where, with increasing experience, the diversity of the pedagogical links and teacher talk moves utilised by the teachers declined. This study recommends that teacher training programmes incorporate the scientific story, using analogies and talk moves in the science education module syllabi. It also recommends that future studies focus on the relationship between teaching experience and actual teaching practice.

Keywords: Teacher talk moves; Pedagogical link-making; Life Sciences; Scientific story; Classroom talk

Language editor's disclaimer

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PhD candidate
Wits University

Ethics Statement

The author of this dissertation, whose name is displayed in the title page, has obtained the required and necessary research ethics approval for the research described in this dissertation. The author declares that ethical standards required as stipulated by the code of ethics for research and policy guidelines for responsible research were observed.

Dedication

I dedicate this research to my high school Life Sciences teachers, Ms. Elsa Masemola, Ms. Jessie Baron, and Ms. Lilly Kondowe, who fostered and nurtured my love for the subject. It is by their unwavering patience of my enthusiasm for Life Sciences subject matter that I pursued a career in this field of education and in continuation the study of the instruction of this subject.

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Acronyms and abbreviations

ATM	Analysing teacher moves
CAPS	Curriculum and assessment policy statement
CRM	Connection rejoinder moves
DBE	Department of Basic Education
IEB	Independent Examination Board
IRE	Initiation – response – elaboration
LAIM	Launch initiating moves
LIIM	Literal initiating moves
NSC	National Senior Certificate
PCK	Pedagogical content knowledge
PIIM	Provides information initiating moves
PLM	Pedagogical link-making
PLM-TTMs	Pedagogical link-making-teacher talk moves
RRM	Repeat rejoinder moves
STEM	Science, Technology, Engineering and Mathematics
TTM	Teacher talk moves
URM	Uptake rejoinder moves

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CHAPTER 1: GENERAL ORIENTATION

1.1 Introduction

The goal of this chapter is to provide an overview of this study. It starts by presenting relevant background information. Following this, it considers the problem that this study addresses, which connects to the aims, objectives, research questions, and rationale of the study. It also provides a summary of the methodology utilised in the carrying out of this study. It ends with brief descriptions of the chapters as they appear in the dissertation.

1.2 Background information

Talk plays an integral role in many teaching and learning contexts. Michaels and O'Connor (2012) state that talk is not an auxiliary, but rather a vital central tool and a critical component of any teaching and learning episode. The role of talk remains central for many science classrooms across the world, as science teachers are required to use teacher talk moves to communicate science ideas. Teacher talk moves are defined as discursive practices, in particular, utterances that teachers use to elicit learners' thinking, to promote scientific reasoning, to encourage learners to elaborate on their thought processes in order to aid understanding and to construct knowledge in learning communities (Penuel et al., 2012). Research on teacher talk moves is not new. Scholars have studied the way in which teacher talk moves are used to request evidence or reasoning from learners and to build on the contributions of learners to develop classroom discussions focused on meaning. For example, Buma and Nyamupangedengu (2020) investigated the teacher talk moves that were utilised in basic genetics lessons in a teacher educator's classroom, whereas Khoza and Msimanga (2021) aimed to understand the effect and nature of questions and follow-up teacher talk moves in science classrooms. However, teacher talk moves can be used to do more than this, since they can be used to develop the scientific story (Soysal, 2022; Yildiz-Feyziogle, 2024). That is teacher talk moves can be utilised to make pedagogical links that play an integral role in developing the scientific story. This assumption stems from the work of Mortimer and Scott (2003), where the authors introduced an approach that characterises the talk between teachers and their learners and termed it communicative approaches.

Scott et al. (2011) examined pedagogical link-making (PLM) in relation to communicative approaches. Communicative approaches are characterised by the use of teacher talk moves and now seen as science classroom discourses (Khoza & Msimanga, 2021). The previous statement implies that, in order to enact particular communicative approaches, teacher talk moves are utilised as tools. The term PLM relates to a process central to the instruction of conceptual knowledge in science and of other subject matter in other discipline forms (Scott et al., 2011). PLM is also a framework that combines integral instruction processes such as the use of prior knowledge in science classrooms (Sexton, 2020). It is, therefore, utilised in instruction, for the construction of meaning through the constant linking of concepts by teachers and their learners amidst classroom interactions in science classrooms (Mudadigwa & Msimanga, 2019). This linking can occur in three forms, namely PLM to support the building of knowledge, PLM to promote continuity, as well as PLM to encourage emotional engagement (Lehesvuori & Ametller, 2021). I explore these forms in the literature review chapter. Provided that PLM considers how teachers and learners link concepts during classroom interactions, various communicative approaches may be utilised in order to carry out the linking in any of the three forms of PLM. This has been supported by Scott et al.'s (2011) declaration in their study that PLM is a dialogic process and the results of their study that indicate that various communicative approaches are used to address the making of links. Since communicative approaches are characterised by teacher talk moves, I took the view that there could be some connection between the teacher talk moves utilised and the PLM forms promoted in Life Sciences classrooms; even more so, as PLM or rather linking is seen during classroom interactions. Scott et al. (2011) merely identified the types of communicative approaches that addressed the forms of link-making but did not refer as to how these communicative approaches can be utilised to promote pedagogical links. This study, therefore, aimed at looking at this connection, by exploring how certain teacher talk moves can be attributed to forms of PLM. What propelled this was the Grade 12 diagnostic reports of the Life Sciences National Senior Certificate that highlighted common errors which can be traced back to Grade 10 content that forms the base of the concepts in the examination.

1.3 Research problem

The Life Sciences Curriculum and Assessment Policy Statement (CAPS) stipulates that Life Sciences as a school subject is comprised of a variety of science sub-disciplines i.e., microbiology, zoology, biotechnology, entomology, biochemistry, genetics, botany, anatomy, taxonomy, environmental studies, physiology, morphology, and socio-biology (DBE, 2011). Raven et al. (2019) describe how science sub-disciplines are related to each other by highlighting the significance of their relationships. They (Raven et al., 2019) state that understanding concepts of molecular levels of Life Sciences leads to an in-depth understanding of the organismal level concepts, which in turn leads to a deeper understanding of concepts on a population level. Understanding these connections leads to an improved understanding of concepts on both community and ecosystem levels of Life Sciences. As this pertains to the sub-disciplines microbiology and biochemistry, these prove essential to the explanation and understanding of genetics, which then contributes properly to the understanding and explanation of taxonomical, physiological, morphological and anatomical concepts, where understanding these concepts contributes to the understanding of biotechnology, botany, zoology, socio-biology, and environmental studies. An example of how these sub-disciplines are related can be seen in the explanation of how fauna (zoology sub-discipline) are related (taxonomy sub-discipline) though the aid of molecular evidence (genetic and biochemistry sub-disciplines) along with physical features (physiology, morphology, and anatomy sub-disciplines) (Pough et al., 2022). As such, the relationships between the ideas of these sub-disciplines of Life Sciences are integral in the teaching and learning of Life Sciences, for the construction of meaning in order to ensure scientific understanding (Lehesvuori & Ametller, 2021). This is not only isolated to South African science classrooms, as affirmed by Lehesvuori and Ametller (2021), who argue that science classrooms remain the central fora in which knowledge fragments are brought together for coherent construction.

CAPS further stipulates that Life Sciences teachers ought to aid their learners to identify links between topics that are related even across grades so that they obtain in-depth understanding of the interconnectedness of life and nature (DBE, 2011). In science education, linking topics has value, where for example in their paper on gamification in science education, Kalogiannakis et al. (2021) highlight the importance of linking concepts from different scientific fields in achieving the goal of science education towards scientific literacy. The value of linking has also been emphasised prior by Sikorski and Hammer (2017) in their paper on looking for coherence in the science curriculum. These two authors assert that building meaningful and consistent relationships between information constitutes a vital principle in the explanation and justification of science. Chittum et al. (2017) also stressed the importance of making links in their paper on the effects of an afternoon Science, Technology, Engineering and Mathematics (STEM) programme on the engagement and motivation of students. In a study that examined ChatGPT in the sense of science education, it was furthermore stressed that the making of connections between classroom learning and real-world applications is essential for science teaching to be effective (Cooper, 2023). It can therefore be deduced that the making of links is essential in the teaching and learning of science.

In the Life Sciences CAPS document, it is stated that Grade 10 is the entry grade for Life Sciences and that as such the first section within the syllabus in Grade 10 focuses on Subject Orientation (DBE, 2011). This implies that although this section is not assessable, it is vital to a learners' Life Sciences education from Grade 10 until Grade 12. This can be seen in the Life Sciences Grade 12 diagnostic reports ranging from 2018 to 2023 whereby skills taught in the orientation section of the syllabus in Grade 10 are listed under common errors made i.e., labelling of drawings, interpreting diagrams and spelling out of terms (DBE, 2020; 2021; 2023). In addition, common topics whereby Grade 12 learners made numerous errors on, in the final National Senior Certificate (NSC) from 2018 to 2022 include meiosis, mitosis, and evolution (DBE, 2020; 2021; 2023). Consequently, these topics that seem to pose challenges to the Life Sciences NSC results, are topics whose base is introduced in Grade 10. This is supported by explicit statements in the Life Sciences CAPS document where, in outlining the Grade 12 syllabus, it is mentioned that mitosis, meiosis and the cell cycle ought to be linked back to Grade 10. It was also mentioned that the genesis of ideas about evolutionary origins ought to be linked to Grade 10, and it was outlined in the Grade 10 syllabus that the human skeleton is integral to the topic of human evolution in Grade 12 (DBE, 2011). It can be gleaned on that Grade 10 Life Sciences has a great influence on Grade 12 Life Sciences teaching, learning, and academic performance.

As stated above, the CAPS document clearly stipulates that Life Sciences teachers ought to be able to make links, however, although it at times outlines how different topics and grades connect, there is no mention of how these teachers might go about making those links. As such, exploring tools and/or approaches that would aid in making links in the classroom is of utmost importance, where the focus on PLM and the teacher talk moves utilised in Grade 10 Life Sciences classrooms. However, this was not the sole reason for examining teacher talk moves and PLM.

1.4 Rationale

Following multiple searches on the following databases: ScienceDirect, SA ePublications, Google Scholar, EBSCOhost along with Taylor and Francis (Journals), there are numerous publications of papers on concepts relating to PLM i.e., Sikorski and Hammer's (2016) paper on conceptual knowledge and Ausubel's (1963; 1968) papers on prior knowledge, approximately thirteen on the PLM framework alone have been published. The multiple database searches were conducted from the December 2022 to October 2024. From amongst those papers, only one elaborates on a study set in South Africa, whereas all the others elaborate on studies set in Brazil and in European countries (across different science sub-disciplines and schooling levels). The paper on the study set in South Africa was authored by Mudadigwa and Msimanga

(2019), whose study was set in Physical Sciences classrooms, which leaves a gap for PLM framework studies conducted within South African Life Sciences classrooms. Three studies from those on the PLM framework i.e., Lehesvuori and Ametller (2021), Rocksen and Olander (2016) and Scott et al. (2011) have focused on link-making and communicative approaches. For instance, the seminal paper by Scott et al. (2011) linked PLM to communicative approaches and vice versa by examining how each communicative approach was used to address a particular pedagogical link. Despite the assertion on the part of Scott et al. (2011) that connections were established, none of the three studies attempted to link PLM forms to teacher talk moves or vice versa. As mentioned, teacher talk moves can be classified into particular communicative approaches thereby making them more specific than a general communicative approach. For this reason, examining the manner in which these approaches play a role in addressing the making of certain pedagogical links would serve science education research. The study aims to address a literature gap on PLM in science education, including classroom talk as a whole as well as on the connection between PLM and classroom talk.

In their papers, Mudadigwa and Msimanga (2019), along with De Quadros et al. (2018b) assert the linking concepts for conceptual understanding and for reducing gaps engendered by knowledge fragmentation in science classrooms. As stated in the problem statement, Life Sciences teachers in South Africa are expected to make links between the various topics taught within the subject and the relevant content that the learners may have come across in their schooling careers and their everyday lives. Since the linking of concepts is crucial and constitutes a requirement in South African

Life Sciences lessons, this study proposes to augment extant knowledge on how to link particular concepts so as to ensure conceptual understanding.

Coldwell et al. (2017) mentions that research conducted in the field of education at the bare minimum proffers a vision informed by evidence of how teaching practices might be improved. Consequently, another justification for carrying out this study is the improvement of the quality of teaching and learning. I am cognisant of the fact that the improvement may not be immediate. However, a study such as this one is usually accessed by postgraduate students and academic scholars who eventually, or rather, in most cases, become teacher educators in some shape or form. The implication is that what they gather from this study may later be used in lectures and/or curricula in the field of science education (Coldwell et al., 2017). This would ensure that novice teachers and/or continuously trained teachers are well-versed in PLM and teacher talk moves, thereby improving the quality of teaching and learning of Life Sciences as they are in possession of tools that can better facilitate the linking of concepts as stipulated by the Life Sciences CAPS document.

The last rationale for conducting this study is purely personal. As a result of focusing on PLM in my honours degree research report, I am deeply fascinated by PLM and to some extent curious to discover and explore the place of PLM within the science education scope and am eager to pursue any possible connection that this phenomenon has with any education theories and/or concepts. This provides an intrinsic explanation as to why PLM and teacher talk moves were chosen for scrutiny.

1.5 Aims and objectives of the study

The aim of this proposed qualitative study was to explore how teacher talk moves are used by Grade 10 Life Sciences teachers to promote pedagogical links in their classrooms. The following objectives were set out for this study:

- to determine the pedagogical links made in the classrooms of the Grade 10 Life Sciences teachers;
- to document the ways in which pedagogical links are promoted through the use of teacher talk moves; and
- to determine the factors that influence Grade 10 Life Sciences teachers' use of talk moves to promote pedagogical link-making

1.6 Research questions

The main questions that guided this study were as follows:

How do Grade 10 Life Sciences teachers use teacher talk moves to promote pedagogical links in their classrooms?

The main question is addressed by asking the following sub-questions:

1. What pedagogical links are made by Grade 10 Life Sciences teachers in their classrooms?

   This study assumed that links were made or attempts to make links were done in Grade 10 Life Sciences classrooms. This has been the case in PLM studies that have been conducted in Life Sciences related teaching and/or learning contexts i.e., the study by Martins et al. (2018) set in General Pathology classes, which reported that meso and micro (continuity) links were made in those classrooms. It was vital to know which pedagogical links were made by each Grade 10 Life Sciences educator before looking at the teacher talk moves used here to promote them; hence, this question constitutes the initial research question.

2. In what ways do the Grade 10 Life Sciences teachers use teacher talk moves to promote the pedagogical links?

   This study was grounded in the assertion that communicative approaches were utilised to make pedagogical links, where this consequently led to this study looking at teacher talk moves as a manner to further explore the above-mentioned assertion as such this question was structured in such a way that the pedagogical links made by each Grade 10 Life Sciences teacher could be further explored, in the sense of classroom talk, by analysing for teacher talk moves in attempts to explore the relationships between pedagogical links and the teacher talk moves used to make them.

3. What influences the Grade 10 Life Sciences teachers' use of talk moves to promote pedagogical link-making?

   This study acknowledged that exploring these phenomena meant more than just observing them but interrogating them in order to enhance the understanding of the phenomena. Considering that PLM and Teacher talk moves constitute tools that teachers could utilise in their science classrooms, exploring these would also include discovering the factors that could potentially influence when and how they were used by the Grade 10 Life Sciences classrooms.

1.7 Definition of key terms

- Instruction

In the field of education, the term instruction has a dual meaning. The first being a direction or order (Collins, n.d.) and the latter referring to the act of teaching (Britannica, n.d.). In this dissertation, the latter meaning is implied whenever the term 'instruction' appears. In such case where a direction or order is discussed, the word instruction is replaced by direction or order, so as to avoid possible confusion of the use of the term.

- Life Sciences

According to the Merriam-Webster Dictionary, Life Sciences is a science branch that involves the study of living organisms and life processes. This definition found in numerous dictionaries (Cambridge, n.d.; Collins, n.d.; Merriam-Webster, n.d.) is similar to that of the term 'Biology', thereby implying that Life Sciences is synonymous to Biology in most cases. Life Sciences is, in fact, much broader than biology in terms of the quantity of fields of study. As such, Life Sciences in this dissertation adheres to the above-mentioned definition.

- Pedagogical link

The term pedagogical link refers to connections among experiences, ideas, and concepts (Scott et al., 2011). In this dissertation, this definition derived from Scott et al. (2011), the PLM framework introducers, is implied whenever the term pedagogical link appears.

- Teacher talk moves

Talk moves are referred to as utterances (Ganesh et al., 2021) and as dialogic acts (Wang et al., 2023). Lazzerini (2020) refers to teacher talk moves as tools that teachers can skilfully utilise to support learning, engagement, and participation. Hu and Chen (2023) also refer to talk moves as tools that are able to provide teachers with feedback. Talk moves are not just utilised by teachers, but also by learners. Since this study focused on teachers, the term teacher talk moves is considered applicable. The above elaborations apply to term teacher talk moves. In this dissertation, whenever the term teacher talk moves appears, it refers to utterances that teachers utilise skilfully to support learning, engagement, participation, and to obtain feedback.

1.8 Summary of research methodology

This study was underpinned by an interpretivist paradigm and consequently follows a qualitative research methodology, with its main aim being to explore the phenomenon of how teacher talk moves were utilised to promote pedagogical links in Grade 10 Life Sciences classrooms. A case study design was utilised, where each teacher and their Grade 10 Life Sciences classroom were treated as a single case. The selection of participants, Grade 10 Life Sciences teachers, was both purposive and convenient. Key criteria, such as currently teaching Life Sciences in Grade 10, and being an able participant, were met, and the first three participants fitting the criteria, were selected as the participants of this study. The Grade 10 Life Sciences educators, their school principals, learners in their Grade 10 Life Sciences classrooms, along with their parents, provided their written informed consent by means of consent and assent forms prior to the collection of data. Video recordings of three lessons conducted by each teacher were observed and each individual participant's interview transcript stemmed from the video data. The video recordings were transcribed and analysed by means of an analytical framework that stemmed from the conceptual framework. Subsequent interviews were conducted with the Grade 10 Life Sciences teachers in order to gain more insight into particular events that occurred in their video-recorded lessons. The interviews were later transcribed and analysed through both inductive and deductive reasoning i.e., analysis of narratives and narrative analysis. This will be discussed further in-depth in Chapter 3.

1.9 Organisational structure of dissertation

Chapter 1: General orientation

Chapter 1 introduces the study of focus of this dissertation by providing background based on literature of the study, presenting the research problem, discussing the rationale behind pursuing the research problem, outlining the aims, objectives and research questions that guided the study, clarifying key terms used in the dissertation, and discussing the delineations, limitations, and assumptions.

Chapter 2: Literature review and conceptual framework

This chapter presents the theoretical basis of the study of focus by discussing, analysing the literature pertaining to this study and placing this study within extant literature. The study is also framed conceptually in this chapter, with a conceptual framework guiding the study is presented here.

Chapter 3: Research design and methodology

In this chapter, an interpretivist paradigm underpinning the study, the justification for the choice of this paradigm, along with its impact on the rest of the research methods of the study are presented. The quantitative methodological approach along with the multiple case study research design are discussed here in terms of the reason why they apply to this study, their weaknesses, and why those weaknesses do not affect the study and/or are overcome in the study. The ideal participants, selected using purposive and convenience sampling, are outlined, and justified as ideal for the study in this chapter. The manner in which data was collected by means of interviews and video data are elaborated on in terms of instruments used, the advantages and disadvantages of using the data collection methods, and instruments and evidence of validity of those. Narrative analysis, analysis of narratives, and an analytical framework used to analyse the data are presented here, along with the measures that were adhered to, to assure the quality and ethical nature of the study.

Chapter 4: Data presentation and data analysis for the first case study

In this chapter, the first case is presented. Then the data collected from the first case's Video data is presented as per secondary research question one and two. The data collected from the interview conducted with the first case is then presented as per the third secondary research question. Lastly, a summary of the findings made from the first case's data is presented.

Chapter 5: Data presentation and data analysis for the second case study

In this chapter, the second case is presented. Then the data collected from the second case's Video data is presented as per secondary research question one and two. The data collected from the interview conducted with the second case is then presented as per the third secondary research question. Lastly, a summary of the findings made from the second case's data is presented.

Chapter 6: Data presentation and data analysis for the third case study

In this chapter, the third case is presented. Then the data collected from the third case's Video data is presented as per secondary research question one and two. The data collected from the interview conducted with the third case is then presented as per the third secondary research question. Lastly, a summary of the findings made from the third case's data is presented.

Chapter 7: Discussions, conclusions, and recommendations

This chapter presents a summary of the findings presented in chapters four to six and then further presents the conclusions of this particular study. The research questions of this study are answered here. Furthermore, the study is reflected on. Lastly, professional, and future research recommendations are provided.

CHAPTER 2: LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1 Chapter introduction

The previous chapter introduced the study and the layout of the dissertation. In this chapter, a composition of the systematic, thematic, conceptual, and argumentative literature reviews is presented, along with the conceptual framework. The literature review is composed of the traits from the above-mentioned reviews for the following specific reasons. This study is grounded in an assumption and as such highlighting literature that supports or rather refutes this assumption is essential. This study also attempts to presume a relationship between the key topics of focus therefore it was also beneficial to categorise and describe the relationships. It was also vital and logical to have structure in the form of themes.

This literature review commences by looking at the manner in which science concepts are taught, as discrete ideas, in an attempt to argue for the necessity of Pedagogical Link-Making (PLM) and Teacher Talk moves. This then leads to an examination of how this teaching of science as discrete ideas has been compensated for in educational systems i.e., coherence in curricula, coherence in assessment, and coherence in lessons, which then leads to the following sections that cast an eye on the ways in which coherence can be achieved in lessons, that is, PLM, communicative approaches, and Teacher talk moves. This review then highlights the possible influencing factors to using particular pedagogical links and teacher talk moves. Following the literature review section, the detailed conceptual framework that drives this particular study is then presented and this chapter then ends of with a chapter conclusion to tie off the literature that drives to this study.

2.2 Literature review

2.2.1 Teaching science as discrete concepts

Scientific concepts have been defined by Lantolf et al. (2021) as generalisations of humans' scientific experiences and as knowledge contents, which are relatively compartmentalised and presented in a detached and separate manner (Santos et al., 2017). Life Sciences too, as a science, also has concepts. Koran (1971) states that concepts are used in Life Sciences as representations of all natural phenomena and objects i.e., genetic trait inheritance and a Kiaat tree. Brigandt (2020) corroborates that concepts in Life Sciences refer to scientific events. These above-mentioned concepts are taught as discrete ideas in science classrooms. This teaching of scientific concepts as discrete ideas has acquired multiple terms i.e., fragmented learning model, micro-learning, and sequenced learning (Billingsley & Ramos Arias, 2017; Chen et al., 2015; Fogarty, 1991; Liang et al., 2023; Pereira et al., 2020; Santos et al., 2017; Wang & Zhang, 2019; Xavier, 2019; Jiang, 2018).

Sequenced learning examines the scientific curriculum through separate lens that are connected by means of a common frame (Fogarty, 1991). This education idea defines the structure of concepts as hierarchical and is based on established learning progress and research (Chen et al., 2015). Behind this is that topics are taught discretely, but are arranged in sequences, such that the prior learnt/ taught topics are able to provide a broad framework to future concepts, which are related (Fogarty, 1991). This educational idea is somewhat vital in curriculum studies, and has influenced the drafting processes of numerous curricula, such as the curriculum implemented in the South African mainstream public schools known as the Curriculum and Assessment Policy Statement (CAPS). The reasoning for this is that the Grade 10 Life Sciences

CAPS curriculum exhibits features of sequenced learning, where for example, topics such as the human skeleton are deliberately placed in Grade 10 in order to set the ground for the human evolution topic taught in Grade 12, which requires knowledge of the human skeleton. Mitosis is placed in Grade 10 to also set the ground for reproduction and cell division, which are taught in Grade 12 (DBE, 2011). The fragmented learning model shares similar properties.

The fragmented learning model can be thought of as the traditional curriculum organising model (Fogarty, 1991), where reasons for this will now be made relevant. This model dictates that concepts within a curriculum ought to be divided into separate and distinct subjects such as in modern day school and universities (Kansanen, 2009). Liang et al. (2023) mention that utilising this model allows for learners to acquire discrete knowledge on different spaces and time pockets, making this model complementary to formalised and systematic learning (Wang & Zhang, 2019; Jiang, 2018). Since Life Sciences is a subject, whose content was clearly curated and used to frame it as a distinct and separate subject from the other subjects in the South African school curriculum, it is justified to state that the fragmented learning model has been utilised alongside sequenced learning in the drafting of the CAPS curriculum. Micro-learning, though fairly different, still shares particular characteristics with sequenced learning and the fragmented learning model.

Not much is known about micro-learning, however it shares the properties of the fragmented learning model, which stipulates that knowledge is shared in smaller increments for extended time periods (Marques & Xavier, 2019). Marques and Xavier (2019) states that this type of teaching of concepts as discrete ideas has existed for a long time. From these three highlighted 'terms' it can be gleaned that concepts in the South African school curriculum, including that of science, are taught discreetly. This accepted reality of teaching science concepts as discrete ideas has enormous implications for the science education landscape.

Billingsley and Ramos Arias (2017) highlight one of the implications of the teaching of science concepts as discrete ideas. They (Billingsley & Ramos Arias, 2017) state from a pedagogical point of view that it is difficult for learners to bridge between subject disciplines, due to the rigid boundaries of compartmentalisation created in secondary schools. Pereira et al. (2020) add to this by mentioning that the knowledge gathered about a particular domain is limited, and is comprised of numerous separate components, which are not intertwined, thereby leading the oversimplification of knowledge along with misconceptions that may hinder learners from making meaning of how these concepts can be collectively used. Liang et al. (2023) proceed to highlight that fragmented learning, as a manner of teaching science concepts as discrete ideas, displays a strong sense of incompleteness. Wang and Zhung (2019) argue that, although it is greatly applicable to system learning such as formal learning, it is not conducive to system learning, due to its nature as a form of non-coherent thinking; and Santos et al. (2017) stress that teaching these concepts as discrete ideas ultimately fails to assist learners in ultimately meeting the demands of modern society outside the classroom. From this one can garner that, although there have been numerous educational ideas and/or models that have advocated for the teaching of concepts as discrete ideas, it is evident that although necessary for the structured teaching of scientific concepts, this is to some extent detrimental to the meaning-making process of science more generally. This concern has motivated numerous empirical studies in the field of Life Sciences education.

Empirical studies such as those conducted by De Quadros et al. (2018a), De Quadros et al. (2018b), Lehesvuori and Ametller (2021) and Roehrig et al. (2021) have been driven by the implications of teaching scientific concepts as discrete ideas, particularly compartmentalisation. Lehesvuori and Ametller's (2021) study explored PLM as a theory and its coherence within science in response to the fragmentation of knowledge in science classrooms. These authors highlight that science classrooms are still the areas whereby fragments of information are brought together. Roehrig et al. (2021) argues that learning is restricted by the artificial separation of subject areas in their paper on their study on understanding integration and coherence within an integrated Science, Technology, Engineering and Mathematics (STEM) curriculum. De Quadros et al. (2018b) asserts that compartmentalisation creates knowledge gaps at schools, which leaves science learners lost in the middle of numerous science concepts, in their study that analysed PLM in science classrooms in higher education. In another study that considered the utilisation of PLM in organic chemistry lectures in higher education as a possible strategy to taper fragmentation, De Quadros et al. (2018a) stress that curricula in higher education undergraduate courses is fragmented. From these four studies, one can reasonably state that compartmentalisation and/or fragmentation of knowledge in science is a pressing issue, and that consequently, these studies also centre around ways in which this teaching of science concepts as discrete ideas can be manoeuvred to reduce its negative implications and impacts.

Wang and Zhang (2019) state that the adverse effects of learning concepts as discrete ideas can be avoided, or rather reduced by placing and implementing certain measures and means such as organisation strategies. Although not explicitly mentioned, Zohar (2023) imply a means to reduce the negative impacts of teaching concepts as discrete ideas. They (Zohar, 2023) stipulate that science should be taught not as a body of knowledge comprised of fixed facts but as a way of promoting thinking. Billingsley and Ramos Arias (2017) list strategies such as crossing the curriculum, asking about other lessons, data-centric mind mapping, scientific cross-matching and went as far as highlighting that the National Curriculum in the country in which their study was conducted provides teachers with the opportunity to create links between various, separate subjects. From these strategies, one can garner that at the core of these strategies a key driving factor that may allow these strategies to aid in reducing the negative implications of teaching concepts as discrete ideas, is coherence.

2.2.2 Coherence as a critical concept

Coherent examinations, teacher instruction, and formal curriculum standards have been equated to the increased learning of learners in countries that are developed (Atuhurra & Kaffenberger, 2020). Coherence is variously defined in numerous dictionaries. The term refers to a situation or state whereby all the pieces or ideas fit well together in order to form a whole that is unified (Collins Dictionary, online). The Cambridge Dictionary (online) emphasises the clear relationship between the pieces of a whole in their common definition of coherence. The Oxford Learner's Dictionaries (online) describe it as a circumstance whereby all the components of a particular thing fit well together. The Free Dictionary (online) defines coherence as the relationships between parts that are orderly, logical, and aesthetically consistent. The Merriam-Webster Dictionary (online) also defines it as a logical order of integrated components.

In the Longman Dictionary (online), coherence is elucidated as connected or rather united members of a group due to shared common beliefs, aims and qualities. It has also been described as a logical internal consistency by Worsnip (2018). From these dictionary definitions, the term is, or rather relevant terms are associated with 'components', 'logical' and 'integration'. As such, the general meaning of coherence can be gleaned as the logical integration of the components of a whole. This mainstream meaning of coherence does not differ from the meaning of coherence in the education field.

Numerous educational scholars have attempted to define coherence in the context of education. Waller (2015) defines it as the well-fitting together of everything. Sherman et al. (2010) define it, in the context of the instruction of English, as the smooth flow of connected sentences and ideas. It has also been understood as the alignment of notions about teaching and learning along with its artifacts (Heredia, 2019). Polikoff et al. (2020) define it as the linkage of the key components within an education system. It has also been defined as an educators' abilities to align and connect resources in order to carry out a strategy meant for learning improvement. Although phrased divergently, these definitions of coherence still draw back to the colloquial meaning of coherence i.e., the logical integration of the components of a whole in this case being the logical integration of certain components of particular aspects of education. This definition, though more specific, holds true to coherence in science education.

Schmidt et al. (2011) define coherence in science education as the articulation of concepts as a sequence of performances and topics over time, according to the hierarchical and logical nature of discipline content from which the subject-matter is derived. Schmidt et al.'s definition of coherence still holds in Heredia's (2019) paper exploring the role of coherence, in the learning of science formative assessment. Penuel et al. (2022) elucidate coherence as the sought-after group of connections between scientific ideas that learners require in their progression of their schooling. It has been referred to as the consistency and interrelatedness of explanations, theories, principles, and evidence in science (Sikorski and Hammer, 2017). It is further evident that the definition of coherence in science still reiterates the mainstream definition, where, instead of components, the definition now features scientific ideas, or rather, scientific concepts. As such, coherence in science education can be defined as the logical integration of concepts in science. It stands to reason that this logical integration is paramount in the field of science education.

Recent research, along with efforts for science education reform consistently stress the vitality of science instruction that is coherent (Nordine et al., 2021). McPhail (2021) reinforces the need for coherence in science instruction in his paper on a curriculum coherence model, arguing that teachers ought to be able to identify the main concepts in a subject and/or topic along with the interrelationships between them in order to foster material learner engagements with their particular concepts. Bernatova et al (2020) present a visualisation of the logical structure of a curriculum that is ecologically and biologically oriented, also stress some form of coherence relating back to Bruner's argument that learners understand an entire topic whenever they understand the way the subject matter is structured. In addition, studies such as those conducted by Beier et al. (2018) as well as Schneider et al. (2021) contain empirical evidence that is in support of coherent instruction; Schneider et al. (2021)'s study, for instance focused on finding ways to reduce irrelevant cognitive process in order to best organise knowledge in concept maps that teachers can utilise.

As argued above, that coherence in science classrooms is essential, as such it makes sense that a wide pool of research on coherence exists. Areas of interest that have been explored on coherence in science classrooms include an aligned curriculum, aligned instruction and assessment, the impact of coherent education on student engagement, and interest along with the impact of coherent instruction on the long-term retention of knowledge.

Several strategies can be used to ensure coherence in education. The first, curriculum alignment, has already been noted as a major focus area of coherence research (Atuhurra & Kaffenberger, 2022; Fortus et al., 2015; Roehrig et al., 2021; Sikorski & Hammer, 2017; Sundberg, 2022). The term curriculum alignment has been referred to as curriculum fidelity and coherent curriculum in certain education research contexts (Bay, 2016). Curriculum alignment or curriculum coherence refers to the arrangement of learning standards and/or knowledge from international and national expectations to local and classroom domains with regards to the assessment, goals, and content of teaching and learning practices (Sundberg, 2022). McPhail's (2021) study set out to present a curriculum design model as a way to eliminate and/or to reduce the issues learners had with electricity i.e., their difficult in generalising from a concept, their blunders with electrical concepts along their inadequate specialised language required to discuss concepts. Coherence research focuses on curriculum alignment, and McPhail (2021) aimed to confront curriculum fragmentation and a dearth of curriculum design coherence in order to ensure coherence. Articles by Roehrig et al. (2021) and

Sikorski and Hammer (2017) also consider an aligned curriculum. Sikorski and Hammer (2021) argue that endeavours taken to build coherence into curricula reflect misconceptions that are rudimentary and enduring regarding the nature of coherence; whereas Roehrig et al. (2021) aims to understand coherence in an integrated STEM curriculum. An aligned curriculum necessarily requires aligned assessment. (Bonner et al., 2018; Heredia, 2020).

Assessment alignment refers to assessments that are structured based on the set standards i.e., objectives, to be used to guide instruction and to improve achievement (Polikoff et al., 2011). The South African public school system administers aligned assessments each school term, and every year, despite the curriculum, CAPS, or Independent Examination Board (IEB), is utilised by various schools. Heredia's (2019) study analysed how coherence issues were managed in the development of science-specific formative assessment. Aligned assessment requires aligned instruction (Carrillo et al., 2019; Jin et al., 2019; Minami, 2021; Neumann & Nordine, 2022; Zuckerman & Lawson, 2017). This can be seen for instance, in Neumann and Nordine's (2022) study where the authors consider how instructional coherence develops the competence of students in physics. The authors state that, in order to develop competence, coherence between instruction and educational aims ought to exist within units and/or across school years.

Instructional alignment refers to teaching that demonstrates the coordination between the learning objectives and instructional practices utilised to facilitate those learning objectives along with assessments that serve as evidence of the learners' ability to attain those learning objectives (McPhail et al., 2021). It includes use of consistent terminology to ensure coherence and relating scientific ideas to real-world contexts (Nordine et al., 2021). This also involves the integration of skills, along with the fostering of connections between disciplines to ensure coherence in science classrooms (Duschl, 2019; Ummels et al., 2015). Vertical alignment (Jordens et al., 2016), also ensures instructional alignment, which refers to the established competencies that learners are taught in a simple lesson, subject or grade that prepares them for their next study level that has higher competencies. The use of technology also serves as another means to ensure instructional alignment (Kewalramani & Arnott, 2020; Newmann & Nordine, 2020; Tague & Czocher, 2016). Cherbow et al. (2020) analyse the emergence of coherence among system levels and components in science instruction and how it influenced alignment. Nordine et al. (2021) meanwhile argue that science teacher education programmes must be coherent in order to play an integral role in promoting coherent instruction in schools. It is evident in their aims that these above-mentioned studies focused on instructional and assessment alignment in order to achieve coherence. Reiser et al. (2021) present an instructional model of storylines as an approach for engaging learners, focusing on the impact of coherence on learner engagement.

The place of PLM in science education research lies in the strategies that may aid in coherence in science classrooms i.e., curriculum alignment, instructional alignment, consistent terminology, real-world contexts, vertical alignment, interdisciplinary connections, and the use of technology. In cases where either of these strategies are discussed, examined and/or researched, PLM, is simultaneously though not explicitly discussed, examined and/or researched. In other words, these strategies are necessarily vital in the making of pedagogical links, where, whenever these strategies are in use, pedagogical link-making is being practised. This particular study places greater focus on the teacher, who, in multiple coherence contexts, plays an integral role. A number of the highlighted strategies require a certain element of talk from the teacher in order to aid coherence. As such, the place of this study, whose main focus – in the broader scope of science education research is in coherence – is PLM and teacher talk moves.

2.2.3 Teachers' perceptions and experiences of teaching for coherence

A cursory literature search on the perceptions and experiences of teachers with regards to teaching for coherence led instead to literature on coherent teacher education programmes (Athanases & Oliveira, 2010; Barton & Elliott, 2024; Paesani, 2020; Tan & Amiel, 2022; Villegas & Lucas, 2002). To this author's knowledge Cobb et al. (2020) consider systems that aid in creating coherence during instruction as one of the few academic studies that even mention teachers' influences in the creating of such systems. As this study was focused on Grade 10 Life Sciences classrooms, the plethora of literature found on coherent teacher programs will not receive further attention. Instead, it is noted that the primary implementers of coherence, viz. teachers, both perceive and have experienced teaching for coherence. This is a research gap that pedagogical link-making, an instructional strategy that can be utilised to foster coherence in science classrooms, can attempt bridge. As such this particular study did not only examine pedagogical link-making and teacher talk moves as instructional strategies that can be used to foster coherence, it also focused on the factors that influenced the use of these strategy, thereby trailblazing a path towards acquiring teachers' thoughts and perceptions of teaching for coherence.

2.2.4 Pedagogical link-making: The process

It was established in the previous sub-section that PLM is related to coherence by briefly mentioning its relation to the strategies that are utilised to ensure coherence. The forms of link-making to be thoroughly discussed in the next sub-section and the strategies to ensure coherence are similar in nature, as they discuss identical notions. It is therefore essential to first look at the process of PLM before unfolding on the relation between PLM and coherence.

2.2.4.1 What the process of PLM entails

PLM is an underlying process in many science educational contexts. A seminal paper by Scott et al. (2011) argues that PLM is a basal aspect in the teaching and/or learning of conceptual knowledge in science. PLM has been diversely defined by various science education scholars. Prior to its terming as PLM, the process itself was elucidated by Tunnicliffe and Ueckert (2007) who emphasise the connections within and between grades and subject areas in order to allow students to connect ideas and to develop in-depth understandings. It has also been defined as the process of connecting ideas explicitly during the teaching and learning process (Lehesvuori & Ametller, 2021). Mudadigwa and Msimanga (2019) defined PLM as a teaching and learning process, whereby learners and their teachers interlink concepts in a constant progression to make meaning during classroom interactions. Scott et al. (2011) as well as De Quadros et al. (2018a) also refer to the notion of PLM as those forms in which teachers and their learners relate to concepts to construct knowledge in classrooms and/or other educational contexts. I will, however, be looking at Grade 10 Life Sciences teachers in my proposed study, and not the learners. Thus, this definition of PLM leans towards the forms in which Grade 10 Life Sciences teachers relate concepts in order to facilitate the construction of knowledge in their classrooms.

2.2.4.2 The importance of the process of PLM

Focusing on clusters of related concepts has been recommended by Pereira et al. (2020) as an instructional strategy to alleviate the compartmentalisation of knowledge, which, as stated earlier, is how science knowledge is structured. De Quadros et al. (2018a; 2018b) along with Parr and McNaughton (2014) stress the fundamentality of making links in the teaching and learning of sciences. Their arguments, though already strengthened by the results of their respective studies, are supported by Rocksen and Olander (2017), who state that the importance of establishing links between concepts is evident in the natural sciences, where practices that are referential are of significant value in the quest to advance scientific arguments, which has revealed the vitality of classroom teaching that is continuous and not as events that are temporarily bound. Here, Rocksen and Olander's (2017) statement links the process of PLM to natural sciences ever-advancing arguments. This particular study agrees with Rocksen and Olander (2017) for the following reason. Life Sciences is the precursor secondary education subject to higher education natural sciences courses and modules, and as such, learners are exposed to and also being taught about the explicit links between various concepts, which may, in higher education, be located in separate sub-disciplines of natural sciences. This could possibly make them scientists who are better at noticing and exploring certain trends and relationships, thereby leading to better scientific arguments. However, PLM is not just significant for future purposes. In the context of Mathematics, a STEM (Science, Technology, Engineering and Mathematics) subject, making links has deepened learners' understanding of concepts and procedures in mathematics as tools that can be utilised to solve problems (Meng et al. 2023). Though not outlined further, the study conducted by Rocksen and Olander (2017) suggests that PLM serves numerous concurrent functions in a classroom, where Bruner's argument, as stipulated by Bernatova et al. (2020), note that *it is easier for learners to understand an entire topic when they understand how their subject matter is structured.*

Link-making was intended for learners to develop a deep understanding of concepts by connecting ideas. Pereira et al.'s (2020) states in this regard that it is essential to explore the relationships between concepts throughout a course in order to increasingly emphasise that relationship and to construct a network of those concepts – the essence of making pedagogical links – in order to prevent both misconceptions and oversimplification, which make for poor sense-making. Pereira et al.'s (2020) statement is further supported by Watkins and Manz's (2022) assertion that sensemaking includes overlapping processes of proposing, relating, and refining ideas, along with *seeking coherence across* experiences and ideas. This adheres to two of the three conditions of meaningful learning in Ausubel's (1963) theory, where new knowledge is linked to previous knowledge in PLM, which is a condition of meaningful learning (see PLM form to support the building of knowledge in the next sub-section) and which adheres to the meaningful learning condition that stipulates those learners must be provided with opportunities to form non-arbitrary links with existing schemas (Da Silva, 2020; Gilewski et al., 2019). The condition of learners' intent to logically assimilate new knowledge into their existing schemas is not considered as only the two are relevant to the focus of this study. It is clearly evident from the above that PLM is a process essential to sense-making in science classrooms. This remains true in this study as well, as one of the problems that prompted this study centred around the detected common errors made by Grade 12 learners in their Life Sciences matric exams that displayed flaws in their sense-making processes. As such, in a broader context, this study views PLM as a process that can be utilised to facilitate sense-making in Life Sciences classrooms.

2.2.4.3 Aspects and processes similar to PLM

The integral process of PLM is similar to a variety of teaching approaches. These teaching approaches include the germ-cell approach (Engestrom, 2020), concept-based instruction (CBI) (Garcia, 2018) as well as systematic-theoretical instruction (STI) (Erfanrad & Fazilatfar, 2020). The germ-cell approach was introduced by Davydov in 1990 as a teaching approach that actualised a movement from abstract concepts to concrete concepts, whereby learners' understanding of the construction and interrelationships of scientific concepts is explicitly facilitated by activities (Hedegaard, 2020). Concept-based instruction is a teaching approach that fosters learners' active interactions with concepts in a manner that is systematic, significant, and coherent (Garcia, 2018). Systematic-theoretical instruction is a teaching approach where scientific concepts are declared as minimal units of instructions and are materialised and verbalised to be presented as an interconnected schema to learners (Chi Wui, 2023). The terms 'interrelationships', 'interconnected' and 'coherent' along with 'scientific concepts' appear in the elaborations of the various teaching approaches, this suggests that, although they may vary when they are divulged deeper, these approaches along with PLM are essentially a process that elucidate the relationships between scientific concepts to the learners explicitly, which, to some extent, share certain core aspects.

The aforementioned teaching approaches and PLM entail certain aspects that have all been declared integral to any science classroom. The first aspect on this list is that the learning and teaching process of science ought to be based on everyday events and/or societal situations in order to enable the gist of science and its overall meaningfulness (Tunnicliffe & Ueckert, 2007; Watkins & Manz, 2022; Zidny et al., 2021). This relates back to the original ideas of Vygotsky on scientific and spontaneous concepts (Duran, 2018), which is elaborated in the next section. The second aspect revolves around representations i.e., verbal, gestures, and drawing (Meng et al., 2023). Bernatova et al. (2020) adds on to this list of representations to also include graphs, maps, Venn diagrams, tables, structure diagrams and development diagrams. Their vitality is not limited to science, where Frigg, and Nguyen (2020) mention that our everyday lives are permeated by representations, for example, the viewing of traffic lights to cross the road, the reading of novels, and the contemplation of paintings. Frigg and Nguyen (2020) thereby highlight why representations are vital in science classrooms, showing how humans make sense of the world by pronounced if not fundamental use of representations. The representations in a science classroom make it possible for learners to mobilise knowledge (Mainali, 2021). Kokkonen and Schalk (2021) also agree with Mainali (2021), stating that teachers' use of external representations helps learners to acquire science and mathematics competencies and knowledge. These representations are vital because they comprise the language of communication, which scientists use and because they are utilised to explain, predict, and model the unique aspects of physical occurrences (Ralph & Lewis, 2020). These representations serve as surrogates to which teachers can off-load cognitive processing demands to with the aim of supporting, reasoning, and thinking (Kokkonen & Schalk, 2021). To do this effectively, multiple representations are used in order to capture a scientific concept's entirety and to describe the aspects of a system that are related (Hansen & Richland, 2020) Even Munfaridah et al. (2021) in their paper of multiple representations use in Physics (a branch of science) also reiterate the vitality of using multiple representations. They (Munfaridah et al., 2021) state that the use of different modes of representations is common in contemporary classrooms because they increase the accessibility of abstract and complex concepts through different forms of visualisation and thus enhances the learning of the learners.

The third aspect is relating prior knowledge to new knowledge. Duchy et al. (1999) assert that prior knowledge is an integral learning variable, and that both correct understandings and misconceptions can be classified as prior knowledge. This assertion has been stated numerous times in many inaugural educational theory papers such as in Ausubel's subsumption theory (Ausubel, 1962). Ausubel's subsumption theory elaborates that learning within humans takes place through the process of connecting new events to their cognitive concepts, which already exist (Teane, 2019). Schuh (2017) cements prior knowledge as an essential aspect of science instruction, by starting that it has been the focus of many studies, and has frequently been tied to knowledge structures in these studies. This too remains the case in Scott et al. (2011) paper on PLM. These three above-mentioned vital aspects are incorporated and arranged in the PLM in order to support the building of knowledge form of the PLM framework to be unpacked in the sub-section to follow.

The last vital aspect revolves around narratives, or rather storylines, which are heavily linked to the PLM form to promote continuity found in the PLM framework. A dearth of published work exists with a focus on the utilisation of narratives as an effective teaching strategy (Kromka & Goodboy, 2019). As such, this particular study focuses on the PLM from to promote continuity as well. Meng et al. (2023) refer to narratives as linking a sequence of episodes within a lesson. This linking can, however, be done within a single lesson, between a series of lessons and even years (Scott et al., 2011). This study follows Scott et al. (2011) for the several lessons it covers. Although understudied, the use of narratives is integral. Landrum (2019) suggests that presenting knowledge in a narrative structure enables an easier comprehension on the part of learners due to their in-depth internalisation of how stories are told. Kromka and Goodboy (2019) also reiterate this by stating that narratives may lead to the acquisition and retention of knowledge, due to the fact that they are memorable and easily retrievable. These authors corroborate Strube (1994) regarding the need for structure to a narrative that arranges concepts in a manner that is acceptable, easy to assimilate, and memorable. With this still holding true decades later, narratives reveal themselves to be a vital aspect of teaching and learning, especially in science instructional contexts, where discrete concepts have to be bought together in an attempt to aid learners in meaning making. This is also reiterated by Landrum (2019), Kromka and Goodboy (2019) as well as Lehesvuori and Ametller (2021). Landrum (2019) along with Kromka and Goodboy (2019), who state that narratives may be considered foundational to instruction. Lehesvuori and Ametller (2021) likewise acknowledged narratives as impactful to student learning.

This process is outlined in-depth through the use of three forms of PLM comprised of 10 link-making approaches that have been identified and arranged into a framework that can be used to analyse teaching and/or learning by Scott et al. (2011).

2.2.5 Pedagogical link-making: The framework

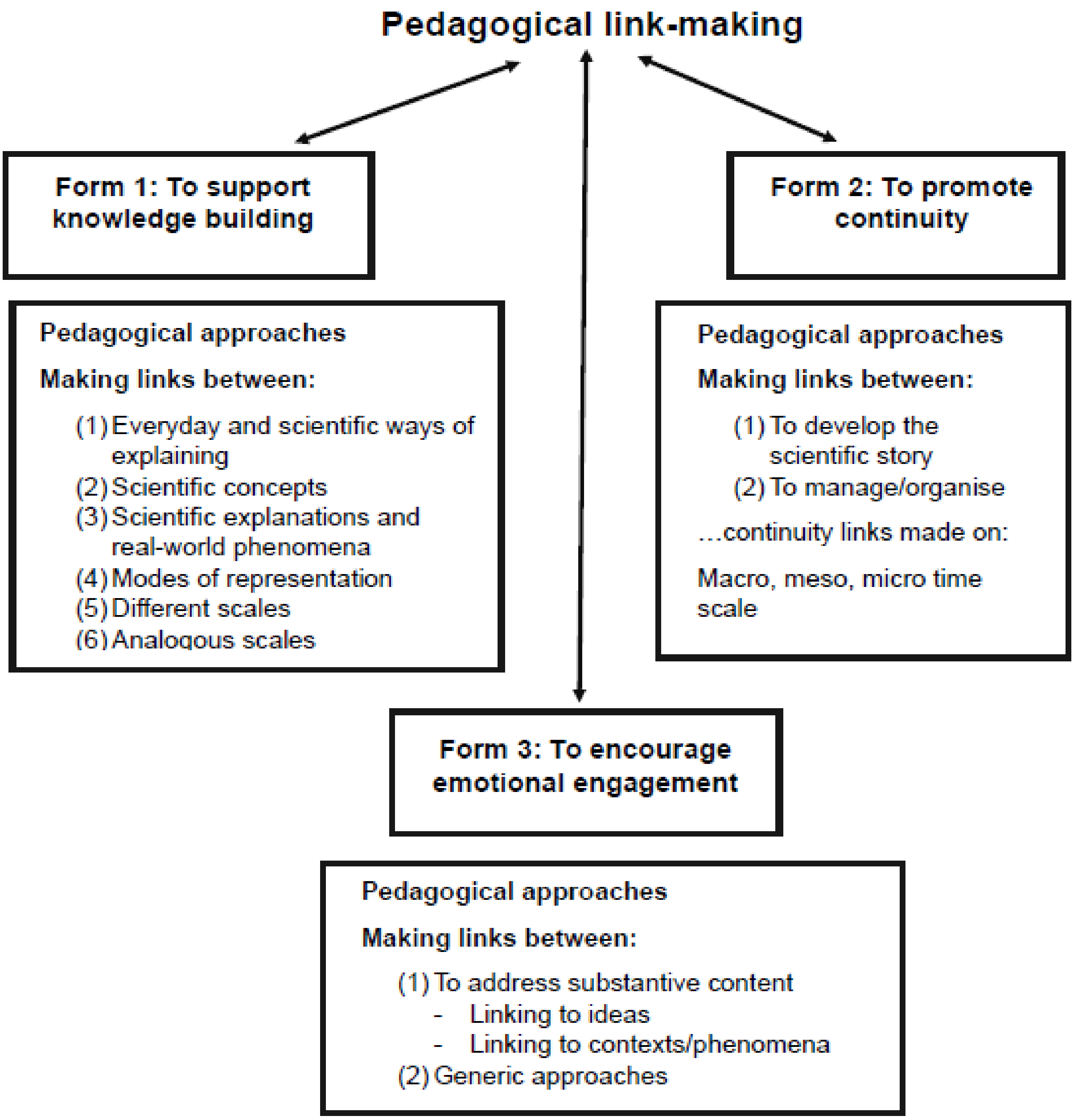

Figure 2.1: Scott et al.'s (2011) pedagogical link-making framework (p.30)

The PLM framework, as can be seen in Figure 2.1 above, consists of three forms namely PLM to support the building of knowledge, PLM to promote continuity and PLM to encourage emotional engagement (De Quadros et al., 2018a). Only the PLM form to support the building of knowledge and the PLM form to promote continuity, were examined in this study. This is due to the fact that the two are interrelated as they focus on the knowledge and not the emotional aspect of teaching Grade 10 Life Sciences. This is supported by Scott et al.'s (2011) assertion that these two above-mentioned concepts overlap. As such, it would be remiss to consider them in isolation.

PLM to support the building of knowledge as a form, addresses all the probable links between various natures of knowledge (De Quadros et al., 2018a) i.e., links between every day and scientific explanations, links between concepts in science, links between real-world occurrences and scientific explanations, links between various representation modes, using analogies and/or shifting between a variety of levels and scales of explanation (Scott et al., 2011). The link between quotidian and scientific explanations is promoted when the common-sense everyday concepts that learners come across are linked to the concepts in school science hierarchical systems, and their elaborations (Scott et al., 2011). Linking various concepts in science involves both highlighting and recognising how scientific concepts fit together in an interlinked system (De Quadros et al., 2018a). Promoting links between real-world occurrences and scientific explanations includes saturating the concrete in the learners' lives with scientific ideas in order to ensure that learners connect the real world with scientific constructs (Scott et al., 2011). The link between various representational modes is promoted by utilising various modalities of representation i.e., pictorial, graphical, diagrammatic, and verbal, of scientific concepts (De Quadros et al., 2018a). Using analogies such as a PLM approach involves using a familiar case to assist learners to make meaning of a target scientific concept (Scott et al., 2011). The pedagogical link of shifting between a variety of levels and scales of explanation is promoted when the teacher moves between the macroscopic levels, the microscopic levels, and/or the symbolic levels of explaining scientific concepts (Scott et al., 2011).

The knowledge building approaches are actually organised science knowledge education core ideas i.e., Vygotsky's perspectives on scientific and spontaneous concepts (Duran, 2018) and systemic property of concepts (Lemke, 1990). The curriculum alignment strategy, along with the vertical alignment strategy to ensure coherence, are similar to the PLM strategy that serves to make links between concepts in science, as the logical sequence of topics aids in the construction of connections between concepts. The PLM strategies to make links between everyday links and scientific explanations, along with using analogies between real-world occurrences and scientific explanations, and the interdisciplinary connections strategies that serve to ensure coherence as they all play a role in showing learner how relevant and interconnected the concepts and/or topic they are learning in fact are. The use of technology as a strategy to ensure coherence is similar to the PLM strategies that make links between various modes of representation, along with shifting between a variety of levels and scales of explanation as these all utilise resources to reinforce and connect scientific concepts.

PLM used to support continuity as a form addresses the links between concepts taught over various time scales (Mudadigwa & Msimanga, 2019) i.e., by developing the scientific story over years, months, weeks, hours and/or minutes and by organising the classroom activities (De Quadros et al., 2018b). developing the scientific story over years, months, weeks, and hours involves making various references to certain topics or activities that were carried out hours, weeks, months or years prior when teaching in the present (Mudadigwa & Msimanga, 2019; Rocksen & Olander, 2017; Scott et al., 2011). Although organising classroom activities is a continuity pedagogical link, It is vital to note that this link does not add new elements to the scientific story, but rather, mainly exists to facilitate transitions between activities within a lesson (Scott et al., 2011).

In Sikorski and Hammer (2016), coherence in a science curriculum forms a particular narrative in the sense that learners are continuously exposed to an unfolding story that aids them in linking fragments of scientific knowledge to larger concepts. This is referred to by Scott et al. (2011) as promoting continuity in order to develop the scientific story. Sikorski and Hammer (2016) are backed up by Contini et al. (2020) who build on the findings of De Carvalho (2016), namely that explicit links between science and religion were made as a result of a coherent narrative. The coherence-ensuring strategy of instructional alignment is similar to the entire form of PLM to support continuity as they both build on concepts learnt previously by gradually introducing new concepts. The form used to promote continuity in its entirety is also evident in the coherence ensuring strategy to use terminology consistently across lessons. The strategy to ensure coherence of vertical alignment is related to PLM strategies that serve to develop the scientific story over years (macro), months, weeks (meso), hours and/or minutes (micro), as these ensure a smooth progression of concepts where learners move up a level in their education journey.

Very few studies with a focus on the PLM framework exist, and most of these studies i.e. those of De Quadros et al. (2018a), De Quadros et al. (2018b), Martins et al. (2018) along with Scott et al.'s (2011) pioneering study, were conducted in Brazil. Other studies such as those by Staarman and Ametller (2019) were conducted in Europe. There is a lack of PLM framework studies conducted on the continent of Africa as a whole, as well as in South Africa (the context of my proposed study). To date, only Mudadigwa and Msimanga (2019) conducted a study in the South African classroom, making it the sole study on the PLM framework ever conducted and published on the African continent. It is vital to note that Mudadigwa and Msimanga's (2019) study focused on the PLM form to promote continuity in Physical Sciences classrooms, leaving a remaining gap on PLM framework research in South Africa. This study was based in Grade 10 Life Sciences classrooms in South Africa and serves to address this contextual gap in the literature. It was mentioned in the previous chapter that PLM is a dialogic process, which Scott et al.'s (2011) study did not just focus on the PLM framework, but also on communicative approaches.

2.2.6 The link between communicative approaches and pedagogical link-making

According to Scott et al. (2010), communicative approaches provide a standpoint on how teachers operate with their learners, in order to develop ideas in teaching and/or learning contexts. Their focus on the PLM framework and communicative approaches was foreshadowed by Scott and Ametller's (2007) paper on teaching science in a manner that is meaningful. In that paper, they mention that classroom talk as a whole serves as the means by which the scientific story is introduced. As such, since communicative approaches form an aspect of classroom talk, studying the PLM framework in conjunction with the communicative approaches is justified. In Scott et al. (2011), the four classes of communicative approaches were analysed in order to determine the manner in which the teacher worked with their learners to address the various link-making forms in an attempt to establish the relationships between communicative approaches and the making of links. Their findings showed that the forms of PLM addressed through communicative approaches (Scott et al., 2011) imply that pedagogical links are made by utilising communicative approaches (Scott & Ametller, 2007).

Rocksen and Olander (2016), Lehesvuori and Ametller (2021) along with Lehesvuori et al. (2023) proceeded to study those two main notions (PLM and communicative approaches) in conjunction. Rocksen and Olander (2016) explore the process of link-making in relation to the communicative approaches utilised in the teaching and/or learning of biological evolution. Their study, however, examined the phenomena, and did not further explore the relationship between them Scott et al. (2011). Lehesvuori and Ametller's (2021) study attempted to address the lack of literature which emphasised the vitality of the communication of science concepts through PLM and the utilisation of communicative approaches by determining the enhancement of consistency in PLM and communication in the coordination of classroom discourse. Similarly, Rocksen and Olander (2016), also studied PLM and communicative approaches but did not explore the asserted relationship between the two main notions of focus further. The latest study featuring these two main topics by Lehesvuori et al. (2023) explored the teaching sessions of laboratory teaching assistants, in order to determine the apparency of student-centredness in those sessions. The study was particularly attentive to the interactions and communications between those teaching assistants and the learners, and as such, discovered that student-centredness can be facilitate by using dialogic elements i.e., communicative approaches that elicited the ideas of the learners and linked their experiences to the discussions. Lehesvuori et al. (2023) utilised PLM and communicative approaches as tools to study student-centredness and as such, did not further explore the asserted relationship between the two. It can be gleaned from the literature presented above that the relationship between communicative approaches and PLM has not yet been explored.

2.2.7 Communicative approaches

The term communicative approach has numerous connotations in the field of educational research. In English language teaching, this term refers to a theoretical model considered most effective (Jabeen, 2014). This is a worldwide approach that has made its way into language classes (Sayera, 2019). This study, however, does not consider the connotation of communicative approach, but instead subscribes to and speaks to the connotation in science education of the communicative approach as forwarded by Mortimer and Scott (2003). These authors refer to a communicative approach as a way in which teachers worked with their learners to address the emerging diverse ideas during a lesson. This connotation focuses on inquiring into whether or not teachers take learners' ideas into account in the progression of lessons, and whether these teachers do or do not interact with their learners (Scott & Ametller, 2007). In essence, it characterises talk between learners and their teachers (Mortimer & Scott, 2020; Scott et al., 2010). This study subscribes to this definition of a communicative approach where it attempts to characterise talk between Grade 10 Life Sciences teachers and their learners, while studying how they made meaning through pedagogical links.

Mortimer and Scott's (2003) communicative approaches are utilised in investigating the manner in which science teachers aid their learners in constructing meaning in their classrooms through the use of a variety of interaction patterns and forms of discourse (Aguiar et al., 2010). They serve as talk repertoires strategically deployed by teachers to suit their teaching purposes (Kim & Wilkinson, 2019). This vitality of communicative approaches is both accepted and supported, and even embraced, as a framework that can be utilised to classify and study a teacher's classroom talk, which has led to Kim and Wilkinson's (2019) statement that communicative approaches were developed as part of an analytical framework by Mortimer and Scott (2003), to be utilised to characterise discourse in science classrooms.

The analytical framework led by Mortimer and Scott (2003) consists of five aspects, namely content, teaching purposes, interaction patterns, communicative approaches, as well as teacher interventions. The communicative approaches characterise the classroom talk between a teacher and their learners along either the interactive-non-interactive dimension or the dialogic-authoritative dimension, both of which in general ought to be present in the meaningful teaching of science (Lehtinen et al., 2019; Scott & Ametller, 2007; Scott et al., 2010). Both the dimensions can be combined in order to generate four ways in which teachers may communicate with their learners in their classrooms (Lehtinen et al., 2019; Scott & Ametller, 2007). These include interactive/dialogic, interactive/ authoritative, non-authoritive/ dialogic and non-interactive/ authoritative communicative approaches (Scott et al., 2010). These serve as a basis for this study (due to the assertion) but are not considered here in-depth. Instead, these communicative approaches belonging to an analytical framework map out an interesting relationship between teacher talk moves, a form of teacher intervention (Soysal, 2022), and communicative approaches.

2.2.8 Teacher talk moves

2.2.8.1 What the term Teacher talk moves entails

Teacher talk moves (TTMs) are elucidated as families of moves, utilised in conversations to accomplish local goals (Barnes et al., 2022; Grapin et al., 2019).

Soysal (2021; 2022) defines them as forms of teacher assessment, feedback, and follow-up questions of non-verbal questions or responses. Michaels and O'Connor (2012; 2015) refer to them as moves that are designed to open up conversations. They are also referred to as categorisations of a variety of teacher utterances (Lee et al., 2021). These TTMs are inherently not restricted to classroom contexts (O'Connor and Michaels, 2019). The current study, however, restricts TTMs to the context of Grade 10 Life Sciences classrooms. Penuel et al. (2012) also elaborated on TTMs as discursive practices that are used to promote scientific reasoning, build knowledge in classroom communities, and to elicit student thinking by teachers. Michaels and O'Connor (2015) meanwhile mention that these TTMs change the essence of the talk that takes place between a teacher and their learners, and also amongst the learners themselves. Talk moves, in the greater sense, are able to be utilised by both learners and their teachers in order to construct conversations (Suresh et al., 2018). This study, although acknowledging that learners' utterances cannot be ignored, focuses more on those articulated by teachers, hence the term 'teacher talk moves'. Aranda et al. (2020) also reiterates Michaels and O'Connor's (2012; 2015) reference of TTMs as strategic moves designed to aid teachers in opening up conversations and supporting the involvement of learners. TTMs have also been defined as tools that are generally utilised to facilitate academically productive discussions (Bansal, 2018; Michaels & O'Connor, 2012). Grapin et al. (2019) also support this definition of teacher talk moves as tools. Khoza and Msimanga (2021) further reiterate TTMs as tools by stating that they ought to been seen as tools that teachers can select from to achieve certain goals in their classrooms. O'Connor and Michaels (2019), similar to Lee et al. (2021), further describe teacher talk moves as approximately utterance-sized units of classroom talk intended to elicit responses or to bring particular concepts to the table. My study acknowledged teacher talk moves as tools, but embodied O'Connor and Michaels' (2019) definition of teacher talk moves. Compared to communicative approaches, teacher talk moves can be straightforward in the sense that they are easy to remember and carry out (Michaels & O'Connor, 2015). As such, it is justified to mention that teacher talk moves characterise communicative approaches, as these are utterances, and not whole approaches. My study took the view that teacher talk moves are more specific than communicative approaches, as they characterise those approaches, as such studying teacher talk moves in conjunction with PLM to establish a link between the two, further explores Scott et al.'s (2011) assertion of the relationship that exists between communicative approaches and PLM.

2.2.8.2 The importance of TTMs

TTMs are essential forms of classroom talk, due to their multiple functionalities as social tools, cognitive tools, and pedagogical tools (Khong et al., 2019). My study mainly explores their functionality as pedagogical tools. They can be flexibly utilised in any subject domain, classroom setting and at point in any discussion (Michaels & O'Connor, 2012), which makes them highly valuable in any educational context, including the classrooms of Grade 10 Life Sciences teachers who participated in this study. TTMs are generally used to support scaffolded classroom discussions, as well as to support forms of sense making, such as PLM (Barnes et al., 2022; Soysal, 2022). They play a key role in the discipline-specific understanding and intellectual development of learners, in the sense that they influence how learners learn material and also what material those learners learn (Khong et al., 2019). Bansal (2018) also highlights the importance of TTMs in their ability to unearth the deep-rooted misconceptions that learners may have regarding scientific phenomena.

TTMs promote productive dialogue in classrooms, which is essential in the sense that it aids learners to connect their everyday life experiences with their classroom experiences (Lehtinen et al., 2019; Nunez-Oviedo & Clement, 2019; Wang, 2020). Due to their cognitively demanding nature, TTMs play a key role in fostering the reasoning qualities, the construction of argument abilities, and the communication capacities of learners (Soysal, 2021). They also provide learners with opportunities to cultivate productive stances, develop scientific understanding, and to engage in science practices during sense-making conversations (Clarke et al., 2016; Watkins & Manz, 2022). TTMs have also been linked to productive classroom discourse which tends to improve learner achievement (Howe et al., 2019; Suresh et al., 2018). They also play a role in boosting the memorises of learners by allowing learners to make richer associations within lessons (Micheals & O'Connor, 2012). TTMs, as a form of classroom talk, make it possible for teachers to have the opportunity to manipulate the conceptions of learners in ways that support learning that is meaningful. The above-mentioned advantages of utilising TTMs can be best summarised by a statement made by Michaels and O'Connor (2015), namely that well-structured talk has the capability and the capacity to build the mind when used in the context of cognitively demanding tasks. Michaels and O'Connor (2015) reiterate their statement by Tytler and Aranda (2015) that talk has for decades has been recognised as having a central role in knowledge building within science classrooms. This broader context justifies the current study as focused on talk, particularly teacher talk moves, as the foremost drivers of meaning making i.e., PLM.

It is vital to take note that talk moves in general, were conceived originally to serve as a manner to disrupt the dominant IRE form of classroom discourse (Bansal, 2018;

Grinath and Southerland, 2018). The IRE is a traditional classroom interaction pattern where discussions are initiated by a question posed by a teacher, while answers are volunteered by learners and the teacher alike in order to assess the learners' learning by providing evaluative comments (Hudicourt-Barnes, 2003). This form of classroom talk is teacher-led and is also known as recitation (Michaels & O'Connor, 2015). It is sometimes referred to as the triadic dialogue (Wang, 2020). It is used in traditional science instruction (Barnes et al., 2022). This pattern receives conflicting views from numerous scholars. Wang (2020) states that a particular group of researchers believe that IRE produces less dialogic talk and rather more monologic talk, whereas others argue that it has the potential to generate a string dialogic pattern. Scholars such as Tytler and Aranda (2015) believe the former, stating that the IRE limits engagement opportunities for learners by restricting them to engagement using short phrases and words as classroom contributions. Tabach et al. (2019) follow suit with the former by stating that teachers utilise the IRE due to difficulties that they have in supporting learners' reasoning in the classroom. Grinath and Southerland (2018) also subscribe to the former, mentioning that the dominance of the triadic dialog makes discourses such as reasoning crosstalk and explaining rare in science classrooms. The current study, however, subscribes to the latter view, despite the compelling arguments put forth by Tytler and Aranda (2015) and the others. This is because, as Michaels and O'Connor (2015) state that the IRE continuously accounts for more than two-thirds of teacher talk in numerous classrooms, while Buma and Nyamupangedengu (2020) state that the initiating and rejoinder moves (as per the IRE pattern) such as questioning and explaining have been identified as discursive functions that can facilitate productive classroom talk. Initiating and rejoinder moves form part of TTMs.

2.2.8.3 The types of TTMs

Those teacher talk moves are elaborated on by the Analysing Teacher Moves (ATM) framework (Correnti et al., 2015). The ATM framework stresses the role that teacher talk moves play in positioning learners amidst classroom interactions (Khoza & Msimanga, 2021; O'Connor & Michaels, 2019). The ATM framework categorises teacher talk moves into two groups i.e., initiating moves, and rejoinder moves (Aranda et al., 2018; Lee at al., 2021).

Initiating moves refer to the efforts of the teacher to invite the thoughts and participation of learners i.e., launch, literal and/or provides information (Correnti et al., 2015). These can be formatted as questions posed by teachers in diverse classroom teaching fields such as mathematics and science (Soysal, 2011). They are generally utilised to open up discussions and/or classroom conversations (Buma & Nyamupangendengu, 2020; Khoza &Msimanga, 2021; Michaels & O'Connor, 2015). In their study, which aimed to investigate teacher talk moves in teacher education lessons on basic genetics concepts, Buma and Nyamupangendengu (2020) found that the utilisation of higher order initiating as well as rejoinder moves elicited diverse and in-depth answers from students. These initiating moves use questioning strategies that scaffold the thinking of learners and prompt them to think and verbalise their thoughts (Aranda et al., 2020; Howe et al., 2019). However, Khoza and Makgata's (2024) study set in higher education biology classrooms, that sought to understand the interactions of initiating prompts that are utilised to initiate engagement, contradicts the idea that initiating moves can open up discussions and/or classroom conversations. They (Khoza & Makgata, 2024) found out that the use of verbal prompts i.e., questions led to minute student engagement. Lee et al. (2021) made explicit connections between ATM categories of Correnti et al. (2015) and Chapin et al.'s (2009) teacher talk moves.

The rejoinder moves i.e., repeat, uptake, and connection address almost all the teacher talk moves stipulated by Chapin et al. (2009) except wait time. These include prompting learners to further agree, disagree or add, asking learners to elaborate more on their expressed ideas, and requesting learners to restate their peer's expressed ideas (Keeley, 2016). These moves are generally utilised to scaffold learner thinking and to maximise learner participation (Buma & Nyamupangedengu, 2020). At times, the teacher, instead of requesting other learners to repeat a learner's expressed ideas, repeats the idea themselves, and awaits the learner's verification of the statement being what they uttered (Chapin et al., 2003; O'Connor and Michaels, 2019). They are moves generally used by the teacher to clarify the thinking of their learners (Keeley, 2016; Khoza & Msimanga, 2021). In their study on the influence of teachers' responses to the contributions that learners make in science classrooms, Khoza (2023) affirms that teacher noticing -the use of rejoinders- drives the unfolding of interactions in science classrooms. Khoza (2023) further elaborate on why the use of rejoinders/ noticing by teachers is essential by mentioning that not utilising rejoinders denies learners opportunities for in-depth interactions. These moves may also be used to ensure that all the learners in the classroom heard and registered their fellow peer's contribution.

These initiating and rejoinder moves were studied alongside the forms of pedagogical link-making (discussed above) in order to further explore the relationship between

PLM and communicative approaches (this is elaborated more in the conceptual framework section).

2.2.9 Factors that may influence the use of PLM and Teacher talk moves in science classrooms

This study considers that the Grade 10 Life Sciences teachers do not simply arrive at using TTMs to promote the making of particular pedagogical links. This study asserts that the Grade 10 Life Sciences teachers make decisions, whether consciously or subconsciously, at various points within their lessons in order to use certain TTMs and to make particular pedagogical links. This study further extends this assertion by recognising that this decision, whether consciously or subconsciously made, are influenced by certain factors.

Teachers have been classified as independent thinking professionals, who continuously make decisions in environments that are complex and uncertain i.e., classrooms (McGinnis, 1998). For that reason, pedagogical decision-making has been classified as the most complex of crafts (Skeriene & Augustiniene, 2018). This concerns the actions, beliefs, and self-efficacy that teachers expose in their classrooms (Prachagool et al., 2016). These predict the success of educational encounters (Ambusaidi & Al-Maqbali, 2022). Waltzer (2023) in their study on the pedagogical decision-making of early childhood professionals presented the main points when teachers made pedagogical decisions i.e., decisions made for an activity in advance, consciously made decisions in the midst of activities and unconsciously made decisions in the midst of activities.

Amongst many factors further discussed later in this sub-section, teaching experience has been seen as an important factor in the pedagogical decision-making of teachers.

Numerous articles (Gore et al., 2024; Hußner et al, 2023; Podolsky et al., 2019) collectively stipulate that teaching experience is generally enhanced by teaching practice. Podolsky et al. (2019) reviewed thirty studies which positively linked teaching experience to learner achievement, while Hußner et al. (2023) emphasised the importance of practical teaching experience in increasing the self-efficacy of student teachers for reflection. Additionally, Gore et al. (2024) explore how years of teaching experience, particularly within the same grade and subject, improves the teaching quality. These articles, alongside cementing the general notion that teaching experience improves teachers' practice, also indicates the significant influence of teaching experience on teaching decisions. As such teaching experience could serve as a possible influential factor to the Grade 10 Life Sciences teachers' promotion and utilisation of PLM and TTMs.

Another integral factor that may be influential to the use of TTMs to promote PLM is the Grade 10 Life Sciences teachers' pedagogical content knowledge (PCK). PCK is a concept introduced by lee Shulman in the 1980s as a concept that integrates the subject matter knowledge of a teacher with that teacher's pedagogical knowledge (Jacob et al., 2020). PCK can be defined as the teacher's ability to know the teaching strategies that are best suited to aid learners' understanding and to using them (Schiering et al., 2023). Teachers' PCK underpins effective teaching and is a crucial factor that deals with the necessary knowledge a teacher has in order to achieve the aims of teaching. As such, PCK can also serve as an influential factor to the Grade 10 Life Sciences teachers' utilisation of TTMs to promote pedagogical links.

Ambusaidi and Al-Maqbali (2022) in their paper on pedagogical decision-making in science classrooms, draw the reader to longstanding obstacles and challenges in the effective teaching of science. These authors state that some of those obstacles as the lack of resources, lack of exposure to new teaching methods, and the limited content knowledge of teachers. These factors also include contextual factors such as classroom space, resource availability, learners' interests, and learners' skill levels (Gemmink et al., 2021). Shavelson et al.'s (1977) elaboration of the general process of making pedagogical decisions can be linked to other factors, involved such as available teaching methods, the teacher's estimates of the abilities, and the motivations of learners and desired teaching and learning outcomes. These can serve as factors that may possibly influence the use of PLM and TTMs in Grade 10 Life Sciences classrooms. These along with the other factors that the Grade 10 Life Sciences teachers expressed as influential in their used of certain TTMs and pedagogical links may be categorised by the framework of Skeriene and Augustiniene (2018), as either the philosophy of education, the analysis of the needs of the learners, the adjustment of the values of learners and teachers or as the harmony between practice and educational theory.

2.3 Conceptual framework

In the previous section, I discussed that in order to further explore the relationship between PLM and communicative approaches asserted by Scott et al. (2011), I studied teacher talk moves elaborated on in the ATM framework by Correnti et al. (2015) alongside the forms of PLM. Both the teacher talk moves and PLM are grounded in Vygotsky's (1978) sociocultural theory. Multiple studies on teacher talk moves such as that of Barnes et al. (2023) are grounded in sociocultural theory, where Scott et al. (2011) explicitly stipulate in their paper's second section that link-making is grounded in sociocultural theory. As such, this makes sociocultural theory the theoretical basis of the conceptual framework detailed herein.

Sociocultural theory views classrooms as communities of learning where learners form new knowledge and acquire new skills through participation in knowledge building practices, in other words, this theory views learning as an organised social activity that provides learners with the chance to partake in a learning community's practices (Aranda et al., 2020). In the context of this study, the sociocultural theory views the Grade 10 Life Sciences classrooms as learning communities in which the Grade 10 Life Sciences learners participate, in order to acquire new skills and construct new knowledge. In order to unpack the grounding of the ATM framework and PLM in the sociocultural theory, I draw from the mediation concept of this theory. Sociocultural theory stipulates that the human action that takes place in both the individual and social plane is mediated by the tools and signs often referred to as 'semiotic means'. These means consist of tools and signs that help to facilitate the co-construction of knowledge and the internalised means to assist learners to independently solve problems (Polly et al., 2018; Scott & Palincsar, 2013). Since teacher talk moves and pedagogical links are utilised in order to aid in the building of knowledge (Keeley, 2016; Penuel et al., 2012; Scott et al., 2011), they can be classified as semiotic means, particularly when it comes to tools as per the sociocultural theory (see Figure 2.2 below).

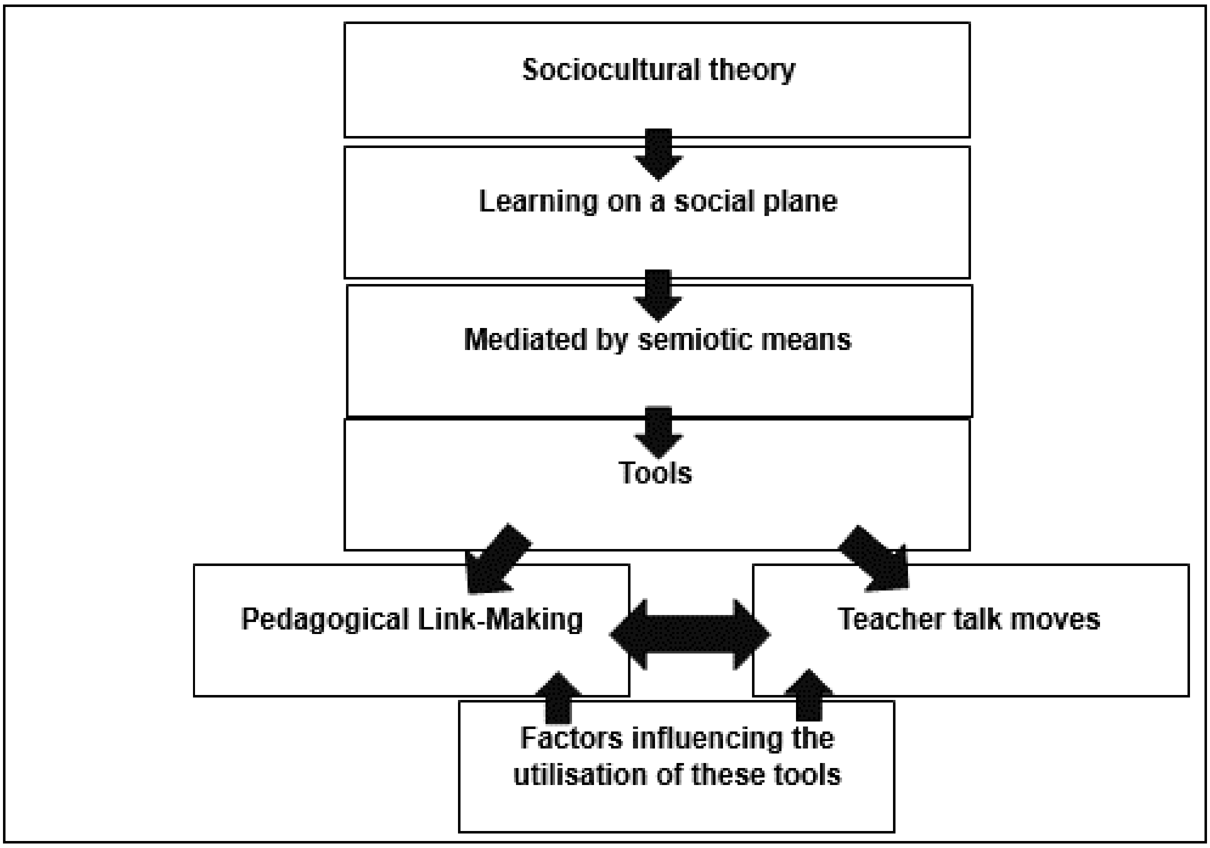

Figure 2.2: Conceptual framework for my study (adapted from Scott et al (2011) PLM and Correnti et al. (2015) ATM frameworks)

As can be seen in Figure 2, the proposed study's framework, termed the PLM-TTMs framework, focuses on the mediation aspect of sociocultural theory by exploring the semiotic means i.e., tools used to mediate learning in learning communities and their relationship with each other. This mediation aspect takes place on a social plane. The social plane refers to social interactions, which in the case of the proposed study, refers to any interactions that learners have with their peers, teachers, and classroom stakeholders i.e., conversations, and classroom discussions. The conceptual framework builds on an assertion by Scott et al. (2011) that there is a relationship between PLM and communicative approaches, by using both the PLM framework and the ATM framework to further explore the relationship between PLM and communicative approaches. It will look at the types of pedagogical links made, and the particular teacher talk moves utilised in the making of those links following the finding of Scott et al.'s (2011) paper that classroom talk particularly communicative approaches are utilised to address the forms of link-making. Therefore, the conceptual framework of this study merges the ATM framework with the PLM framework to further explore the above-mentioned relationship. Only the interrelated forms in the PLM framework, namely PLM to support the building of knowledge and PLM to promote continuity, will form part of the proposed conceptual framework. The utilisation of rejoinder moves will be explored in the making of pedagogical links that are categorised under the PLM form to support continuity and the PLM form to support the building of knowledge. The utilisation of initiating moves was explored in the making of pedagogical links that are categorised under the PLM form to support the building of knowledge, and the PLM form to promote continuity. It would be remiss to assume that these pedagogical tools are merely utilised without any influencing factor, and as such, this study, along with this conceptual framework, allows for a further exploration into teacher talk moves and PLM by enquiring into the possible factors that influenced the use of PLM and teacher talk moves. This exploration provided greater insight into the relationship between classroom talk on a larger scale and PLM.

2.4 Chapter summary

This chapter presented the literature reviewed and presented the conceptual framework that guided the study. Teaching science as discrete concepts, coherence, pedagogical link-making as a process and then as a framework were reviewed. Communicative approaches, teacher talk moves, along with the possible factors that could influence the use of PLM and talk moves in science classrooms, were further reviewed. A conceptual framework based on the sociocultural theory and adapted from both the PLM and the ATM framework was presented and discussed. the next chapter presents the methodology.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.1 Chapter introduction

The previous chapter located the study within the existing literature. This chapter starts by presenting the pilot testing stage, the guiding paradigm, the research methodology and its rationale, research design, selection of participants, sampling methods, data collection methods and data analysis procedures used. Lastly, quality criteria and ethical considerations are outlined.

3.2 Research paradigm

The term paradigm refers to a belief system, a worldview, or an extensive framework that guides the research and practices of a particular field (Kivunja & Kuyini, 2017). In educational research interpretivism and positivism dominate. Positivism determines reality from an objective viewpoint while interpretivism determines reality from a subjective viewpoint (Pham, 2018).

The positivist paradigm has numerous limitations that would have hindered the attainment of this study's objectives. The goal of the social sciences is not just to understand phenomena, but to also be able to make future predictions in order to organise society. The positivist paradigm has no room for this (Jaja et al., 2022). My entire study is based on an assertion that was used to make a prediction, as such making it ill-fitted with positivism. Positivism's core principle of searching for perfect and ideal standards prove unrealistic when the complexity of social phenomena such as teaching and learning episodes are involved (Shah et al., 2020). As such, this study was underpinned by an interpretivist paradigm.

The study aims to explore how Grade 10 Life Sciences teachers utilise teacher talk moves to promote pedagogical links in their classrooms. Interpretivism enables the exploration of multiple realities, including the examination of how pedagogical links are made from a classroom talk perspective. The core belief of interpretivism is that reality is constructed socially (Thanh & Thanh, 2015). That is, the way in which people perceive movement and utterances is influenced by the mind (Potrac et al., 2014). As such, it is able to cater to multiple perspectives and varieties of truths (Tubey et al., 2015). These multiple perspectives of reality can be approached from a variety of angles by numerous people (Rehman & Alharthi, 2015). This aforementioned feature of the paradigm makes it more inclusive, which leads to the attainment of a more comprehensive picture of a phenomenon (Darvishi, 2020). This is possible because interpretivism allows for the focus on the details of a phenomenon which in turn allows for a deeper exploration into the reality behind those details (Ekanoye, 2020). Furthermore, interpretivism suits the study, as it allows the researcher to choose the manner in which they make sense of the data. Interpretivism was also suitable for this study because it enabled examination of the process of link making in Grade 10 Life Sciences classrooms from an angle I desired, which is in relation to teacher talk moves. This paradigm was well-suited for this study because it also allowed deep exploration as per the assertion made by Scott et al. (2011) that communicative approaches are used to make pedagogical links, through their detail-oriented nature.

3.3 Methodological approach

Research methodologies have been defined as strategies that the researcher utilises to map out an approach for enquiry (Groenland & Dana, 2019). Three methodological approaches i.e., quantitative, qualitative, and mixed methods predominate (Maree, 2019). Quantitative research methodologies are utilised in the testing of theories especially in determining the trueness of predictive generalisations of certain theories (Williams, 2021). Qualitative research methodologies, on the other hand, are utilised to attain insights into the beliefs, behaviour, experiences, attitudes, and interactions of people (Mohammed, 2021). The use of elements from both the qualitative and quantitative methodologies is then termed a mixed methods methodological approach (Maree, 2019).

A quantitative research methodology emphasises the 'amounting' of a thing i.e., it investigates or attempts to investigate the responses to questions such as how much, how many and to what extent (Mason et al., 2021). This methodology focuses on aspects of social behaviour that can be measured and patterned (Antwi & Hamza, 2015). Using this methodology is advantageous where generalisability is the goal, because it entails a randomly selected large sample. It is, however, difficult to use this methodology when trying to understand a phenomenon is the goal, due to the snapshot-taking tendency of this method, and due to its nature of not focusing on general meanings of those social phenomena (Rahman, 2020). It is important to note that this study utilised a qualitative research methodology instead of a quantitative or mixed methods approach.

A qualitative methodology is naturally inductive and is used to explore insights and meanings in particular situations (Mohajan, 2018). A number of benefits of utilising the qualitative approach exist. Using this approach enables the production of a detailed descriptions of the opinions, experiences, actions, and feelings of the participants and it enables these to be interpreted in order to make meaning (Rahman, 2020). Utilising this approach allows for a holistic understanding of human experiences and/or phenomena in specific and/or naturalistic settings, making it a flexible methodological approach (Rahman, 2020; Thanh and Thanh, 2015). These characteristics lead to its choice for the current study.

The aim of the current study was to explore PLM and teacher talk moves (phenomena) in Grade 10 Life Sciences classrooms (specific and natural settings), where utilising a qualitative methodology allowed for the exploration these phenomena as they occur in classrooms and to discover and gather insights into these phenomena by producing and analysing the actions, opinions, experiences, and feelings of the Grade 10 Life Sciences teachers. For this reason, it is most suitable because it allows me to gain insight into PLM and teacher talk moves in Grade 10 Life Sciences classrooms.

It would be remiss to ignore that, due to the researcher being more likely to play an interactive role in the data gathering, responses of participants can be affected and/or influenced by the researcher's presence (Thanh & Thanh, 2015; Mohajan, 2018). Another major disadvantage of this methodological approach may be that data collection and analysis can be swayed by the bias and individual tendencies of the researcher. This study aimed to explore PLM and teacher talk moves in Grade 10 Life Sciences classrooms, that is, in particular, the way in which teacher talk moves were used by Grade 10 Life Sciences teachers to promote pedagogical links in their classrooms, rather than to generalize. As such the lack of generalisable data of this methodology does not pose a challenge or limitation to this study.

3.4 Research strategy

The term research strategy refers to a pragmatic plan for carrying out research i.e., how the selection of participants will be carried out, how data will be gathered, and how data will be analysed (Harding, 2018; Maree, 2019). As stated in the previous section, this study adhered to a qualitative methodological approach. Research strategy generally associated with a qualitative research methodology include case studies and ethnographies (Thanh & Thanh, 2015). The ethnography research strategy is utilised to deeply inquire into culture and events in their typical states, whereas case study research strategy studies particular groups in-depth as they naturally occur (Mannik & McGarry, 2017). A distinct difference between the aforementioned research designs is that, when utilising a case study research strategy, the context in which a study is carried out is vital whereas it is not when utilising an ethnography research design (Harding, 2018). This study utilised the case study research strategy, particularly a multiple case study design.

The case study research strategy aims to understand the distinct features of a case that can be defined as a person, a classroom, a policy, a system, a process, an institution and etc. (Thomas, 2021). This study takes the classroom practice of a single Grade 10 Life Sciences teacher as a case study. This research strategy has been found to be particularly valuable in fields that are practice oriented. The study aimed to explore teacher talk moves and PLM, particularly how Grade 10 Life Sciences teachers utilise teacher talk moves to promote pedagogical links, which aims to understand distinct features of a process/ processes, which in the case of this study is the promotion of pedagogical links using teacher talk moves in a practice-oriented field.

Multiple case studies are generally used to denote findings that contrast for reasons that are expected, or that denote similar findings within a study, as this strengthens the findings of a study and makes them reliable (Gustafsson, 2017). Halkias and Neubert (2020) state that using multiple case studies to understand complex phenomena i.e., the case of teacher talk moves to promote pedagogical links, that occur in the context of an existing theory i.e., the utilisation of communicative approaches to make pedagogical links proves methodologically appropriate, as they can confirm or extend the already existing knowledge in the discipline. An advantage of using this research design is that exploration of data was done within its natural context (Zainal, 2007), which in this case is exploration of data on talk moves and PLM in real-life Grade 10 Life Sciences classrooms. Another advantage of using this research strategy is that using it could accomplish high levels of construct validity, where using this research design to determine the teacher talk moves and pedagogical links that the Grade 10 Life Sciences teachers used in their classrooms served to explore how the teacher talk moves are used to promote pedagogical links in Grade 10 Life Sciences classroom (Quintao et al., 2020).

This strategy has certain limitations, such as lack of generalisability, due to its context-specific nature and difficulties to establish cause and effect connections (Queiros et al., 2017). The aim of this study was to explore, not verify, how Grade 10 Life Sciences teachers used teacher talk moves to promote pedagogical links as such the difficulty to generalise data limitation of using this research strategy did not have an impact on the current study. My secondary research questions already address the difficulty to establish cause-effect connections limitation of this research design i.e., the first and second secondary research questions require identification of the pedagogical links and talk moves made by the Grade 10 Life Sciences teacher to direct the researcher to looking at the simultaneous use of PLM and talk moves, thereby helping establish cause-effect connections between talk moves and PLM. It is, however, important to mention that the time-consuming nature of multiple case studies, due to its in-depth involvement with each case (Gustafsson, 2017), was dealt with by maintaining three cases of teachers whose classrooms were observed and by capping the cases of teachers who were interviewed to three, in order to allow for a substantial amount of time to accurately transcribe and analyse the data received from the cases. I am also aware that the combined use of the case study research design according to an interpretivist paradigm and qualitative methodology, are biased and subjective, where decisions that were driven by choice when conducting this study were supported by evidence. That is to say, the selection of participants was supported by a distinct criterion.

3.5 Sampling/ selection of participants

Participants were selected using a purposive sampling method alongside a convenience sampling method. The main goal of the purposive sampling method is to focus on certain characteristics that are of interest, which will be ideal in enabling a researcher to answer their research questions (Rai & Thapa, 2015), whereas the main goal of convenience sampling is to find participants from sources that are suitably accessible to the researcher (Andrade, 2021). This made these sampling methods ideal.

Purposive sampling is a type of sampling not based on the probability by which the researcher makes decisions involving potential participants, based on a variety of criteria that involve required levels of knowledge of the research topic (Rai & Thapa, 2015). Its main advantage is that only populations of specific interest, in this instance, Grade 10 Life Sciences teachers, are studied (Campbell et al., 2020). Convenience sampling is non-probability sampling form, whereby the researcher announces the study and participate select themselves when they wish to participate (Stratton, 2021). The combined use of these sampling methods improves the internal validity and is also disadvantageous because it limits the external validity of a study due to its non-generalisability.

My study was based in two South African public secondary schools, School A and School B, particularly Grade 10 Life Sciences classrooms in Gauteng Province townships. The majority of schools in South Africa are public (state-owned) (Galal, 2022) and in Gauteng, most of these public schools are situated in townships. Setting the study in public township schools was justified by its broader relevance, as most Grade 10 Life Sciences classrooms in the Gauteng Province are found in such schools. A township school in South Africa refers to schools found in low-income areas i.e., in informal settlements and state low-income housing and are generally fully funded by the state, where the learners and their guardians are not required to contribute funds. The number of schools were determined by the teachers who were willing to participate in this study.

I worked with three participants who are Grade 10 Life Sciences teachers in township public schools in Gauteng. They could be situated in the same school or in different schools; this depended on the teachers who were willing to participate, as such, not restricting according to school, where the same school provided a wider participant net. An important parameter was that the teachers be Grade 10 Life Sciences teachers. Grade 10 represents the juncture between Natural Sciences and Life Sciences, and thus may provide ample opportunities for link-making, which helped to achieve the aim and objectives. A key requirement when using this sampling method is that participants must be willing to participate and must be able to communicate their experiences and opinions eloquently, meaningfully, and reflectively (Etikan & Bala, 2017). Therefore, the Grade 10 Life Sciences teachers (with varying levels of teaching experience to share) were willing participants who possessed the appropriate communication skills. The following table, Table 3.1, provides the relevant background information of the teachers who formed part of this study.

Table 3.1: Background information on the participants of this study

	Case study 1	**Case study 2**	**Case study 3**
Pseudonym	Musa	Katlego	Peace
Preferred pronouns	He/him	She/her	She/her
Qualifications	Secondary Teacher's Diploma	Bachelor of Education	Bachelor of Education
Life Sciences teaching experience	36 years	8 years	2 years
Other subjects taught	Natural Sciences	None	Natural Sciences

As can be seen in Table 3.1, Musa has more teaching experience than Katlego and Katlego has more experience in teaching Life Sciences than Peace, making Musa the most experienced and Peace the least experienced teacher in this study. Musa and Peace also teach Natural Sciences alongside Life Sciences, whereas Peace solely teaches Life Sciences. They all possess the minimum required qualification to teach Life Sciences and that none of them have pursued furthered their studies.

I am cognisant of the fact that utilising this sampling method made the selection of participants greatly prone to the biases of the researcher (Sharma, 2017). To address this, I ensured that the selection criteria perfectly aligned with the study aim and completely utilised these criteria when selecting participants in order to minimise or rather deal with researcher bias.

3.6 Pilot testing

Pilot testing is a rehearsal, conducted in order to prepare for the carrying out of the study, and may be done specifically to pre-test a particular research instrument (Aung et al., 2021). In this study, pilot testing was done to prepare for the carrying out of interviews and also to pre-test the initial interview schedule I had. The pilot testing was essential in determining the flaws, weaknesses, and limitations that would have negatively impacted data collection, and possibly even the outcome of the study; and allowed for versions to be made prior to implementation (Turner III & Hagstrom-Schmidt, 2022).

The pilot testing in this study addressed the third secondary research question of whether the number of participants had to be the same as those for the interviews; and whether the participants had to remain the same when addressing all the secondary research questions. It is, however, vital to mention that the pilot study did not form part of the main study's data.

A single Grade 10 Life Sciences teacher who fit all the criteria required of a participant was selected from a school different from those in which the participants of this actual study were located. A single teacher was insufficient because the sample size of this study was three Grade 10 Life Sciences teachers.

An interview was conducted with the pilot case via Microsoft Teams (an online meeting platform), where an initial generic interview schedule was utilised to conduct this interview. The interview was recorded with the permission of the participating test teacher and was transcribed. The interview transcript was then analysed inductively and deductively by means of narrative analysis and analysis of narratives.

Upon completion of analysis, the data did not support the main research question of this study, and as such, decreased its feasibility, as the data collected from the interview did not aid in the achievement of this study's objectives. Upon further review of the generic interview schedule, the questions within that schedule were deemed not to fit the study since they did not seem to align with the first and secondary research question, where, as such, the interview schedule was revised. In the initial draft of the interview schedule, the question "explain the role of questioning and your response to learner contributions in your LS classroom" was removed and instead questions such "why do you use incomplete sentences that your learners have to complete?" were utilised in its place; this was mainly done to simplify the question in such a way that the teacher could answer openly without the fear of maybe sounding wrong or unimpressive. This informed the decision of having multiple case studies, whereby each teacher (case)'s lessons would be observed initially and then later analysed. Each teacher's lesson analysis would then be used to generate a specific interview schedule that would be used to interview that particular teacher. This implied that the teacher whose lessons were observed ought to be the same teacher interviewed as this would provide coherent and appropriate data to address the third secondary research question.

3.7 Data collection and documentation

When utilising a case study research design and a qualitative methodology, data collection methods that can be utilised that involve interviews, document analysis, and observations (Petty et al., 2012). My study utilised two research collection methods, namely observations by means of video data, and semi-structured interviews as means to collect data.

3.7.1 Classroom observations and video data

Observations are procedures whereby the behavioural patterns of objects, occurrences and participants are recorded systematically, without communicating or questioning them (Maree, 2019). They are the best available method to utilise when studying classroom practices of teachers (Durdona, 2019), which in this study were the way in which Grade 10 Life Sciences teachers used teacher talk moves to promote pedagogical links, as this gives researchers opportunities to obtain 'live' data (Cohen et al., 2017).

I took on the role of a complete observer in this first stage of the process of collecting data. A complete observer comes close to the idea of an objective observer as they keep a distance to the interactions they observe and is commonly hands off to avoid having any influence on the interactions they observe (Kristiansen, 2022). Since I was exploring PLM and TTMs, it served only to keep a distance from which to observe the phenomenon in question. As such taking the role of the complete observer proved to be the best option. To completely observe, the participants of the study were required to video record any three of their Grade 10 Life Sciences lessons with their smartphones, and to share these with me. Table 1 below alludes to the number of lessons observed per teacher and their focus.

Table 3.2: Number of lessons observed per teacher and their focus

Teacher code and pseudonym	School code	Focus of the lessons	Lesson duration
Teacher 1 (Musa)	School A	Lesson 1: Musculoskeletal system	30 minutes
		Lesson 2: Circulatory system (core ideas)	30 minutes
		Lesson 3: Circulatory system (the heart)	30 minutes
Teacher 2 (Katlego)	School B	Lesson 1: Flow of energy and trophic levels	30 minutes
		Lesson 2: Organisms' adaptations to the environment, food webs and food chains	1 hour (double period)
		Lesson 3: Consolidation of food webs and food chains	30 minutes
Teacher 3 (Peace)	School A	Lesson 1: Kingdom Plantae and Kingdom Animalia	30 minutes
		Lesson 2: Kingdom Protista and Kingdom Fungi	30 minutes
		Lesson 3: Organic compounds	30 minutes

These lessons, as presented in Table 3.2, featured the start until the completion of a topic in the Grade 10 Life Sciences curriculum, and it was not mandatory for the videos from each teacher to feature the same topic, as the specificity of the topic was not the focus of this study. It was only vital that their adhere to the Annual Teaching Plans of the years 20204 and 2025 and that they feature within the same topic or the same week. The data was generated in the months of July 2023 to March 2024. The length of the lessons of each teacher also varied due their school timetabling, the segments where learners were just independently completing activities with the supervision of the teacher within that lesson were not recorded. The independent working part of the lessons were not recorded since these did not include teacher talk, and instead learners work quietly on their assigned activity, this study is focused on how teacher talk is utilised to promote PLM, and as such, this phase of the lesson does not provide the required data to achieve the aims of this study. The three participating teachers were instructed to record their lessons with their camera facing the front of the classroom and were allowed to move the camera when required. This allowed me to see the teachers' use of visuals and artefacts as compared to an audio-recording, which was necessary to be able to analyse for particular pedagogical links under the PLM form to support the building of knowledge i.e., forms of representation and scales and levels of explanation. Continuity links such as meso and macro links can only be observed in a timescale longer than a single lesson (Mudadigwa & Msimanga, 2019), where the above-mentioned number of lessons allowed me to analyse for all the continuity links discussed in the conceptual framework. I am cognisant of the fact that using this as a data collection method was time-consuming and that it made it difficult to acquire data in real-time (Queiros et al., 2017). It is vital to mention that the abovementioned data collection method was applied in the pre-data analysis stage of the research (in an attempt to address the first and second secondary research questions) and that video data was utilised. In the post-data analysis stage of the research, I utilised semi-structured interviews in an attempt to answer the third secondary research question.

3.7.2 Semi-structured interviews

Interviews refer to two-way conversations where participant are asked questions by the interviewer in an attempt to acquire data on the ideas, behaviours, beliefs, views, and opinions (Maree, 2019; McGrath et al., 2019). This data collection method was suitable for the proposed study as it allowed for the examining of teacher' decisions, strategies, beliefs, and values (Gazdag et al., 2019). The flexible nature of interviews allows for participants to explain issues in a manner that they understand and, in that sense, also make it easy for the interviewer to introduce researcher bias (Adhabi & Anozie, 2017). This data collection method is effective in exploring in-depth issues already raised by other methods, in this case Video data, and validate them (Stylianou-Lambert, 2024). In the case of the current study, this collection method allowed me to further explore particular factors that may be influenced by the teachers using certain teacher talk moves to make particular pedagogical links. The semi-structured interviews took place after the video data was analysed. Each of the three teachers was interviewed individually once over an online platform i.e., Microsoft teams (enabled me to record the interview for further reference). These interviews were about 30 to 60 minutes long, and took place after school hours in attempt to not interfere with teaching and/or learning time. Each individual teacher was interviewed based on their unique interview schedule due to the uniqueness of their instructional methods, which displayed a variety of ways in which particular pedagogical links were made through certain teacher talk moves when their observed lessons were analysed (see Appendices A to C for the interview schedules).

3.8 Data analysis

3.8.1 Analysis of video data

The conceptual framework discussed was used to analyse the data collected. The data, video recordings of lessons from Grade 10 Life Sciences teachers' classrooms, which were transcribed to make analysis simpler. The study's conceptual framework incorporated the types of links made under the form to promote continuity and the form to support the building of knowledge, based on Scott et al.'s (2011) PLM framework, along with the teacher talk moves discussed in Correnti et al.'s (2015) ATM framework (see Table 3.3).

Table 3.3: Analytical framework based on the conceptual framework

Pedagogical links		**Teacher talk moves**
Use of analogies		Launch initiating moves (LAIM)
Usage of different scales and levels of explaining		
Connecting various points within a lesson		Literal initiating moves (LIIM)
Using different forms of representation	⟷	
Connecting different scientific concepts to each other		Provides information initiating moves (PIIM)
Connecting every day and scientific explanations		
Connecting occurrences in real-life with scientific explanations		Repeat rejoinder moves (RRM)
Connecting consecutive activities within a lesson		Uptake rejoinder moves (URM)
Connecting various points in a lesson sequence		
Referring to different teaching and learning points within different parts of the science curriculum		Connection rejoinder moves (CRM)

As can be seen in the above presented table, any teacher talk move (presented in the column on the right) may be utilised to promote any of the pedagogical links (presented in the column on the left). Upon the completion of transcribing, the transcripts of the various lessons were printed for the purposes of convenience, and were read through with the goal of identifying cues that imply the making of pedagogical links. The researcher then read through the transcripts again in order to identify cues which indicated the use of particular teacher talk moves. Although the focus was on the teacher, I also coded for learner utterances due to the fact that teacher talk is influenced by learner contributions. A priori coding was used in the analysis of the data. Priori codes are existing codes that are based on prior codes from other researchers or on main concepts of theoretical framework (Stuckey, 2015). This study used the latter as mentioned above. The cues for the pedagogical links were highlighted as per the colour assigned to PLM code, as can be seen in the left-hand column of Table 3.3 (see Appendix D for an example of an analysed lesson transcript) i.e., use of analogies, referring to different teaching and learning points within different parts of the science curriculum, usage of different scales and levels of explaining, connecting consecutive activities within a lesson, connecting various points in a lesson sequence, connecting various points within a lesson, using different forms of representation, connecting different scientific concepts to each other, connecting every day and scientific explanations and/or connecting occurrences in real-life with scientific explanations (Scott et al., 2011). These were the input into the result analysis instrument for Video data (see Appendices E and F). Thereafter, the highlighted pedagogical links were then further analysed for corresponding for teacher talk moves that were utilised, and assigned a code, as can be seen in the right-hand column of Table 3.3 (see Appendix D) i.e., launch initiating moves (utilising open-ended questioning), literal initiating moves (utilising closed-ended questions), provide information initiating moves (relaying information), repeat rejoinder moves (repeating what was just said by a learner), uptake rejoinder moves (utilising a learner's response to steer a lesson) and/or connection rejoinder moves (connecting a learner's response to the next concept to be discussed) (Abdulhamid & Venkat, 2018; Correnti et al., 2015). These TTMs were then also input next to the corresponding pedagogical link in the results analysis instrument for lessons (see Appendix F).

3.8.2 Analysis of data collected through interviews

The study utilised both the analysis of narratives and narrative analysis to make sense of the semi-structured interviews. According to Polkinghorne (1995), in the former approach, categories and themes will emerge from the interviews. In the latter, the teachers' stories of their understanding of talk and link-making in science classrooms were re-told (Polkinghorne, 1995).

Narrative analysis closely examines narratives to interpret human experiences and motivations (Clandinin, 2022). It allows for participants to convey the required research data in their own words, as a means to employ their perception, and to also reveal certain hidden truths (Rahman et al., 2022; Smith & Sparkes, 2009; Yang, 2023). This analysis method allows for the researcher to collect accounts of happenings and events and then proceed to synthesise them into stories by means of a plot (Watson & Mclukie, 2020). Analysis of narratives breaks down narratives into non-narrative form (Watson & Mclukie, 2020).

The narratives are broken down by the identification of common themes (Parks, 2023). The Grade 10 Life Sciences who formed part of this study, were asked to think back on some of their actions and utterances performed during their observed lessons. These participants then responded to the questions posed to them. These responses can be construed as narratives as they feature a retelling or recall of a specific episode (Sandberg, 2022). As these semi-structured interviews were conducted with the means to collect information on the factors that influenced the promotion of links and use of talk moves, these narratives would have to be analysed in order to determine which factors played a role. Since this study's goal was to explore the phenomena of promoting pedagogical links through the use of talk moves, presenting the factors in line with when and how they were used in the lessons (context) would thoroughly present the motivations and experience of those teachers.

This allowed for the interviews to be analysed thematically, and to be presented narratively. This means the transcripts were subjected to both inductive and deductive analysis. Here, the narratives in the interview transcripts were analysed and emerging themes e.g., teaching experience and teacher's PCK were determined. The emerging themes were presented narratively in the following chapters (Chapter 4, 5 and 6).

3.8.3 Summary of data collection methods, instruments, sources, and analysis methods

Table 3.4: A table summarising the data collection and analysis methods utilised in this study

Secondary research question	Data collection method	Data collection instrument	Data source	Data analysis method
What pedagogical links are made Grade 10 Life Sciences teachers in their classrooms?	Video data	Findings instrument for Video data	Teachers (3)	Deductive approach: Analytical framework (see Table 3.3) and result analysis instrument for lessons (see Appendix E)
In what ways do the Grade 10 Life Sciences teachers use teacher talk moves to promote the pedagogical links?	Video data	Findings instrument for Video data	Teachers (3)	Deductive Approach: Analytical framework (see Table 3.3) and result analysis instrument for lessons (see Appendix E)
What influences the Grade 10 Life Sciences teachers' use of teacher talk moves to promote pedagogical link-making	Semi-structured interviews with participating teachers	Interview schedule	Teachers (3)	Inductive and deductive approach: Narrative analysis and analysis of narratives

3.9 Quality assurance

Transferability refers to the extent to which the data of a particular study can be administered to different groups and contexts (Ary et al., 2018). The current study utilised the qualitative methodology and a case study design, both of which already made the data acquired non-generalisable due to their context specificity. Credibility is a qualitative term that refers to the trueness of research findings (Corbin & Strauss, 2015). I utilised theoretical adequacy in this study to ensure credibility, that is, I utilised extended fieldwork and extensive pattern matching (aided by my conceptual framework, analytical framework and/or research questions) to ensure that the findings of the current study are as true as they can be (Cohen et al., 2017; Diaz-Garcia et al., 2021).

Since my study expanded on Scott et al.'s (2011) assertion that there is a relationship between communicative approaches and PLM, some level of dependability was expected. Dependability refers to the consistency of the data of a study when it is replicated under the same conditions (Korstjens & Moser, 2018). Confirmability refers to the ability of a researcher to exhibit data that is based on and representative of the responses of participants and not their won point of view and/or biases (Noble & Smith, 2015). To ensure confirmability, I continuously referred to the research questions, conceptual framework, and analytical framework as guides when selecting data to present in the analysis. The interviews were piloted with one teacher who was not part of the study to ensure confirmability of the data collection method. I also emailed this dissertation draft(s) to the study supervisors such that they were able conduct bias evaluations in order to ensure confirmability.

3.10 Ethical procedures

It is integral to highlight how the ethics considered in this study as researchers are mandated in order to firmly adhere to set ethical standards when preparing for and when conducting research (Ary et al., 2018). Cohen et al. (2017) stress that a competent researcher ought to conduct research, and Miles et al. (2019) states that novice researchers are required to acknowledge their minimal experience and seek out guidance from their research supervisors and teachers.

Upon approval of the proposal, I applied for the ethical clearance and did not attempt to collect data until it was received. I also obtained permission from the DBE in Gauteng. I received informed consent from all stakeholders i.e., the DBE (see Appendix G), The University of Pretoria (see Appendix H), Grade 10 Life Sciences teachers, school principals, University of Pretoria. I discussed the aims with these stakeholders and kept them updated regarding any significant research changes (Maree, 2019). As such, I discussed the proposed study's aims with the relevant party at the DBE, the University of Pretoria and with prospective participants. The sampling method of choice required participants who were willing to participate, where, as such, this also addressed a crucial aspect of ethical standards, whereby it is not permissible or rather it proves unethical to coerce participation. The three Grade 10 Life Sciences teachers who partook in the proposed study were not coerced by myself or any other party and were informed of their right to withdraw their participation in my study at any point in time (Ary et al., 2018). The teachers selected were of legal age and of sound mind.

Privacy is a general issue of concern in research (Harding, 2018). Since the Grade 10 Life Sciences teachers' classroom practice was recorded, it was vital that the Protection of Personal Information Act (POPIA) of 2021 be followed to the latter as the learners in those classrooms need privacy. The principals of schools (see Appendix I), the teachers who served as participants (see Appendix J), the learners in the classes that my participants taught (see Appendix K) along with their parents (see Appendix L) were provided with consent and assent forms, which they signed before they were recorded. I removed any identifiers not relevant to my study's aim in an attempt to achieve anonymity (Ritchie et al., 2014) i.e., used teacher codes and pseudonyms such as Teacher 1 (Musa) in the place of names of teachers, used codes such School A in the place of school names. To maintain a proper standard of writing, the participating teachers were asked to choose gender pronouns which would be used for the sake of reporting the findings in a clear and concise manner. I also ensured that the 'raw data' i.e., video-stimulated interview transcripts and lesson recordings, had restricted access by storing them in password protected device. The raw data was also stored at the University of Pretoria and will continue to be stored there for next 15 years following the completion of this study.

3.11 Chapter summary

This chapter detailed the methods used in the carrying out of this study i.e., interpretivist paradigm, qualitative research approach, multiple case study research design, convenience and purposive sampling, video data, and interviews as data collection methods as well as narrative analysis, analysis of narratives, and an analytical framework as data analysis methods along with quality assurance and ethical measures. The next chapter features the findings of this study as pertains to the first secondary research question.

CHAPTER 4: DATA PRESENTATION AND DATA ANALYSIS FOR THE FIRST CASE STUDY

4.1 Chapter introduction

The previous chapter laid out the research design and methodology of this particular study. In this chapter, I present the findings regarding the first case, Musa, presenting and elaborating more on the pedagogical links he promoted. I then present the Teacher talk moves (TTMs) used to promote the identified pedagogical links. I finally present the identified factors that may have been deciding factors in Musa's use of pedagogical links and TTMs.

4.2 The pedagogical links identified in Musa's lessons

In this section I present the pedagogical links made by Musa. Table 4.1 shows the frequency of pedagogical links made by Musa during the lessons.

Table 4.1: Table illustrating the pedagogical links that were made in each of Musa's lessons

PLM form	Pedagogical link made	Frequency of link made per lesson			Frequency of links made in the lesson sequence
		Lesson 1	Lesson 2	Lesson 3	
		Focus: Skeletal system	Focus: circulatory system (core ideas)	Focus: Circulatory system (The heart)	
To support the building of knowledge	Use of analogies	-	1	-	1
	Using different forms of representation	17	22	15	54
	Using different scales and levels of explaining	10	11	21	42
	Connecting real-life occurrences with scientific explanations	1	-	2	3
	Connecting every day and scientific ways of explaining	5	13	4	22
	Connecting different scientific concepts to each other	2	10	5	17
To promote continuity	Connecting various points within a lesson	-	-	1	1
	Connecting various points within a lesson sequence	1	3	2	6
	Referring to different points in different parts of the science curriculum	-	-	1	1
	Connecting consecutive activities within a lesson	-	-	-	-

In terms of the first PLM to support the building of knowledge, Table 4.1 displays the use of different forms of representation pedagogical link as the most promoted pedagogical link that supports the building of knowledge especially in the first and second lesson. This is followed by using different scales and levels of explaining promoted mostly in the third lesson, as well as connecting everyday scientific explanations promoted mostly in the second lesson. The least promoted link is connecting real-life occurrences with scientific explanations as well as using analogies. What is interesting to note is that Musa was able to promote links by using different forms of representations in Lesson 2, but could not promote any links by connecting real-life explanations with scientific explanations in the same lesson.

In terms of the PLM form to promote continuity, Table 4.1., presents the connecting various points within a lesson sequence as the most promoted continuity promoting pedagogical link. This was done in each of Musa's lessons, and within the entire lesson sequence as well. The other pedagogical links to promote continuity i.e., connecting various points within a lesson along with referring to different points within different parts of the science curriculum were only promoted once by Musa throughout the three lessons. It can be gathered from this that Musa promoted almost all the pedagogical links that were coded for (see Table 3.2 in Chapter 3) with the exception of making connections between consecutive activities in a lesson, in the observed lesson sequence.

4.3 The teacher talk moves used by Musa to promote the identified pedagogical links

In this section, I present the teacher talk moves utilised by Musa to promote pedagogical links, presented in the previous section. For this I use tables and lesson excerpts. I start off by presenting the promoted pedagogical links and their TTMs in a single table to illustrate where the TTMs were utilised and how often they were utilised by Musa

Table 4.2: A table displaying the frequency of TTMs used to promote various pedagogical links each of Musa's lessons

PLM form	Pedagogical links	Lesson number and focus	Teacher Talk moves used					
			LAIM	LIIM	PIIM	RRM	URM	CRM
PLM form to support the building of knowledge	Using different forms of representations	1: Skeletal system	-	6	11	9	4	2
		2: Circulatory system (core ideas)	-	3	26	2	-	3
		3: Circulatory system (The heart)	-	3	13	-	-	-
	Using different scales and levels of explaining	1: Skeletal system	1	8	8	-	2	-
		2: Circulatory system (core ideas)	-	3	11	3	-	2
		3: Circulatory system (The heart)	-	7	13	2	-	1
	Connecting every day and scientific explanations	1: Skeletal system	1	3	2	-	2	-
		2: Circulatory system (core ideas)	-	1	12	-	-	-
		3: Circulatory system (The heart)	1	1	2	2	-	1
	Connecting different scientific concepts to each other	1: Skeletal system	-	2	1	-	1	-
		2: Circulatory system (core ideas)	1	3	7	1	-	-
		3: Circulatory system (The heart)	1	1	4	-	-	-
	Using analogies	1: Skeletal system	-	-	-	-	-	-
		2: Circulatory system (core ideas)	-	-	1	1	-	1
		3: Circulatory system (The heart)	-	-	-	-	-	-
	Connecting real-life occurrences with scientific explanations	1: Skeletal system	-	-	1	-	-	-
		2: Circulatory system (core ideas)	-	-	-	-	-	-
		3: Circulatory system (The heart)	-	-	2	-	-	-
PLM form to promote continuity	Connecting various points within a lesson	1: Skeletal system	-	-	-	-	-	-
		2: Circulatory system (core ideas)	-	1	2	-	-	-
		3: Circulatory system (The heart)	-	-	1	-	-	-

	Connecting various points in a lesson sequence	1: Skeletal system	-	-	1	-	-	-
		2: Circulatory system (core ideas)	-	-	-	-	-	-
		3: Circulatory system (The heart)	-	-	2	-	-	-
	Referring to different teaching and learning points within different parts of the science curriculum	1: Skeletal system	-	-	-	-	-	-
		2: Circulatory system (core ideas)	-	-	-	-	-	-
		3: Circulatory system (The heart)	-	-	-	1	-	-
	Connecting consecutive activities within a lesson	1: Skeletal system	-	-	-	-	-	-
		2: Circulatory system (core ideas)	-	-	-	-	-	-
		3: Circulatory system (The heart)	-	-	-	-	-	-

Table 4.2 above shows that the provides information initiating move (PIIM) was the most utilised talk move by Musa in the promoting of all the nine identified pedagogical links. This is evident as it was used at least once in each of Musa's three lessons. Initiation moves that are used provide information were predominantly utilised in his second lesson that focused on the core ideas of the circulatory system. The literal initiating move (LIIM) was also used abundantly by Musa in the promoting of most of the pedagogical links identified. These literal initiators were predominantly used in his first lesson that focused on the skeletal system. The pedagogical links promoted by Musa to promote continuity were promoted by initiating TTMs only (as can be seen in Table 4.2). Rejoinder TTMs were utilised in supporting the building of knowledge, lesser than the PIIM and the LIIM, and more than the launch initiating moves (LAIM). These rejoinders were also predominantly utilised by Musa in his first lesson that focused on the skeletal system. The rejoinder TTMs were all utilised in the promoting of three pedagogical links, all of which were aimed at knowledge building. This along with the predominant non-use of the LAIM in the promotion of links that allow continuity, illustrate that the launch initiating moves was the least utilised TTM. In other words, Musa utilised launch initiating moves in four pedagogical links in comparison to the other initiating moves, which were utilised more.

The differences in the predominant use of particular talk moves in the various lessons that Musa taught (as presented in the paragraph above) now raises the question as to whether these lessons featured different topics.

The four excerpts below illustrate how TTMs were utilised by Musa to promote the most promoted pedagogical links as presented in the previous section. I first present an excerpt that illustrates how TTMs were utilised to promote the using different forms of representation. This excerpt is taken from Musa's first lesson, where he was discussing the axial skeleton in a lesson that focused on the skeletal system.

Excerpt 4.1: An example of rejoinders that were used by Musa to promote links between different forms of representation

Turn		**Transcript**
74	Musa	Radius again, right. (writes on board). Let's see here (teacher points to where their arm meets their shoulder). Between the clavicle and the humerus. We are having a particular joint that that joint that goes this way (teacher rotates their arm). It goes this way. What kind of joint goes this way? Yes, Learner C?
75	Learner C	Shoulder blade
76	Learner D	Shoulder joint

Excerpt 4.1 features Musa asking learners to name the bones found in the axial skeleton and then proceeds to ask the scientific term for the joints that connect those bones. Musa features a continuation of naming bones and joints that connect them. Turn 74 begins with Musa repeating an answer that the learners provided and then proceeding to write it on the board. By repeating the term 'radius', Musa utilises the repeat rejoinder move and simultaneously connects spoken word to written text by writing radius on the board thus making links between different forms of representation. Further to this, in turn 74, Musa points to the joint where his arm meets his shoulder and then mentions that humans have a particular joint between the clavicle and humerus; Musa furthermore rotates his arm (see Figure 4.1) in order to further show the learners how that joint moves and then asks the learners to provide the name of that joint. By pointing to the joint and then mentioning that it is located between the humerus and the clavicle, Musa provides information (explained by providing information move) to connect the visual representation of the joint to the

phrase 'between humerus and clavicle'. By also rotating the arm to further cement the joint being sought for, Musa also uses the provides information move. The literal initiating move was used by Musa in the asking of the question, where the name of the joint is required from the learners at the end of turn 74. Here, Musa explicitly makes a links between the written representation of the joint and the visual representation of the joint by using the talk move that provides information.

Figure 4.1: A screengrab of Musa using their rotating arm to make a pedagogical link

In the second example, I present an excerpt that illustrates how talk moves were utilised to promote links between different scales and levels of explaining. This excerpt is taken from Musa's second lesson, where Musa was discussing the notion of blood circulation and the types of blood. The focus of the lesson was on the basic concepts of the circulatory system.

In summary, Musa used the repeat rejoinder to link between different forms of representing the term 'radius'. He then proceeded to use the both the literal initiating move and the initiating move that provides information to link the different representation forms of the shoulder joint.

Excerpt 4.2: An example of how information sharing move was used to make links between different scales and levels of explaining

Turn		Transcript
67	Musa	Okay. Let's go to that. Systematic circulation class is the one I was speaking of, that the heart pumps the blood away to the body cells and tissues why? Those tissues, those cells they have what? Dissolved nutrients and energy is not yet released. So, they supply the cells with nutrients together with oxygen for what? For respiration to take place so that energy should be released. Right! Then we are having what? We are having the by-product of respiration, urea, uric acid, carbon dioxide. They are transported. Urea and uric acid will follow the pathway to the kidneys whereas carbon dioxide as a waste gas goes to the lungs. Away with food and energy. Back with what? Carbon…
68	Learners	Dioxide!
69	Musa	Right! (refers to the link diagram) with the oxygen then from the outside through what? Through the pulmonary vein into the heart. Remember the pulmonary vein carries what?
70	Learner E	Deoxygenated.
71	Learner F	Deoxygenated blood.
72	Musa	Pulmonary vein! I said exception to the rule!
73	Learner G	Blood rich in oxygen.

In turn 67, Musa moves from explaining the movement of blood in systematic circulation on a phenomenological level, pumping of blood by the heart to tissues and cells within the board, to explaining it on a microscopic level (Scott et al., 2011). In his explanation, he highlights the concept of respiration, which is a process that occurs in a body cell which is essentially microscopic, in order to explain the presence of carbon dioxide in the bloodstream, which allows for systematic circulation (see turns 69-73). To do this, Musa initially explains what systematic circulation is and then proceeds to use a literal initiating move by asking why the heart pumps blood away towards the cells and tissues (turn 67). However, as he provided information, he both asks and answers questions, so as to provide information. Musa then uses the literal initiating move again by asking what the by-products of respiration are and then proceeds to use the provides information initiating TTM by providing the answer to that question. Here, Musa makes the link between the phenomenological level and the microscopic level of gaseous exchange in the circulatory system, by utilising both the move to provide information and the literal initiator.

In summary, Musa used the initiating move to provide information and then the literal move to link the phenomenological and the microscopic level of blood movement in systematic circulation. He then used the literal and provides information initiating moves again to link the phenomenological and microscopic levels of gaseous exchange.

Excerpt 4.2 bellow that illustrates how TTMs were utilised to promote the connecting every day and scientific ways of explaining pedagogical link. This excerpt is also taken from Musa's first lesson. This lesson considered a discussion of the axial skeleton in a lesson that focused on the skeletal system.

Excerpt 4.3: An example of how Musa used moves that provide information to connect every day and scientific ways of explaining

Turn		Transcript
23	Musa	The axial skeleton. Axial skeleton (writes it on board). Can you name what constitutes the axial skeleton? What makes up the axial skeleton? Yes sir?
24	Learner	The skull
25	Musa	Number one, skull. Number two?
26	Learner F	The backbone
27	Musa	The backbone or what now? Backbone or what?
28	Learners	Vertebral column
29	Musa	(writes it on the board) I like vertebral column. Backbone is English. It is not that scientific. Vertebral column. Yes?

Prior to this excerpt, Musa had asked the learners to name the two main components of the human skeleton and the learners responded by naming the axial skeleton. In turn 23, Musa repeats the answer axial skeleton and then proceeds to write it on the board. The repeating of the answer shows Musa's use of the repeat rejoinder move to link different forms of representation (both the verbal representation of the term axial skeleton and the written representation of the term). Musa then proceeds to use the answer provided to drive the next portion of the lesson by asking the learners to name what constitutes the axial skeleton. By using that axial skeleton answer to drive the lesson, Musa utilised the uptake rejoinder move. Musa then invites the learners to list the bones that make up the axial skeleton. The learners were invited to list the bones through the use of a question; therefore, Musa utilised the literal teacher talk move (see turn 23). In turn 26, Learner F mentions the backbone. In turn 27, Musa acknowledges Learner F's answer as correct by repeating it thus using the repeat rejoinder move. Musa further asks the class to give the scientific name of the backbone, which the learners in turn 28 reply as 'vertebral column'. By asking the learners to give the scientific name of the backbone, Musa utilised the literal initiating move. In turn 29, Musa writes the answer on board and proceeds to repeat it, thereby using the repeat rejoinder TTM and promoting the using different forms of representation pedagogical link. Musa then distinguishes the term 'backbone' as being colloquial, and the term vertebral column as scientific jargon. Here, Musa explicitly makes a link between a common term that learners use in their everyday lives, backbone, and the scientific equivalent of that name 'vertebral column' by using providing information move.

In summary, Musa used a repeat rejoinder to link the different forms of the term 'axial skeleton'. He then used the uptake rejoinder and a literal initiating move to ask learners what constitutes the axial skeleton. Musa then proceeds to use a repeat rejoinder to acknowledge an answer provided by a learner and then used a literal initiating move to ask the learners provide the scientific term for the term 'backbone'. He then used the repeat rejoinder to link the different forms of representation the term 'backbone'. Finally, Musa used provides information to link an everyday term with a scientific term.

The last and fourth is excerpt that illustrates how TTMs were utilised to promote the connecting different scientific concepts to each other pedagogical link. This excerpt is taken from Musa's first lesson, where Musa discusses the axial part of the human skeletal system (this is a continuation of the previous excerpt).

Excerpt 4.4: An example of how initiators and rejoinders were used by Musa connecting different scientific concepts to each other

Turn		**Transcript**
86	Learner E	Suture.
87	Musa	Sutures. They are sutures and they are joined together by what? By the immovable point. They cannot move (writes on the board). They only move during childbirth. During the delivery they can bend so that they must feed through what? Through the birth canal. Do you know the birth canal?
88	Learners	Yes.

Prior to this excerpt, Musa and the learners were discussing parts of the axial skeleton and the joints that are found between those bones that form part of the axial skeleton. Excerpt 4.4 begins with a learner providing the answer to the question Musa posed i.e., the joints found in the skull. In turn 87, Musa repeats the answer provided by Learner E and then builds on that answer, here Musa utilises the repeat rejoinder and the uptake rejoinder TTM. Musa then proceeds to connect the answer of suture joints to the reproductive system by utilising a connection rejoinder and also a provides information move. To do this, Musa mentions the immovable nature of suture joints in the skull (provides information and the uptake rejoinder move are used), a concepts in the skeletal system, and then proceed to provide the only time that nature does not hold true (provides information and connection TTMs used), during the birth of the human by explaining the need for the suture joint going against its nature, which is to allow for the head of the human being birthed to be able to pass through from the uterus to the birth canal, where it leaves the body of the woman giving birth to it (provides information TTM used). Here, Musa explicitly shows how the two body systems, skeletal and reproductive systems, fit together. Therefore, he showed links between two scientific terms by using various talk moves.

In summary, Musa used a repeat rejoinder to acknowledge a learner's answer and then proceeded to the uptake rejoinder to build on to the learner's answer. He then used simultaneously used a provides information move and a connection rejoinder to connect the learner's answer to a different scientific concept. Musa then uses an uptake rejoinder, a connection rejoinder and a provides information move to show how the learner's answer links to a different scientific concept.

As can be seen in Table 4.2, the providing information initiating move is the most utilised TTM in the promotion of the identified pedagogical links and the least utilised was the launch initiating TTM. The reasoning for the use of these TTMs and pedagogical links was not evident in the observed lessons, however an interview was conducted with Musa to determine that reasoning. The results of this interview are presented below.

4.4 The factors that influenced Musa' use of TTMs to promote pedagogical link-making

This study assumes the view that science teachers did not simply arrive at, but rather made conscious or subconscious decisions regarding their pedagogical approaches (Ambusaidi & Al-Maqbali, 2022; McGinnis, 1998; Prachagool et al., 2016; Skeriene & Augustiniene, 2018; Waltzer, 2023). This also applies to using TTMs to promote pedagogical links in science classrooms. However, decisions are influenced by certain factors and as such sought them out. In this section, I present the factors that influenced Musa to make certain pedagogical links and to use particular TTMs. To do this, I use excerpts from the interview transcript of the interview conducted with Musa. I present these narratively, owing to the nature of data analysis described in Chapter 3.

4.4.1 Teacher's PCK

Due to the link made by using different forms of representation being the most utilised by Musa, he was asked whether there was any rationale behind his frequent use of the chalkboard, as it was the most commonly occurring representation form that co-existed with other forms of representation. Musa responded,

> *Yes, it's to foster understanding. And some smart kids, while you teach, they do take notes. And also, it highlights some important aspects that they must be able to recall or touch.*

The numerous phrases that Musa used in his response reflect his PCK. These phrases involve 'foster understanding' and 'highlights some important aspects that they must be able to recall or touch.' In the literature review section, it was stated that PCK includes teachers' ability to know the teaching strategies that are best suited to aid their learners' understanding and using them (Schiering et al., 2023). Prior to being questioned on his chalkboard use, Musa was asked to explain what he thought when he heard the term 'linking' and he replied that, to him, the term 'linking' refers to linking learners' prior knowledge to present knowledge as a way of moving from the known to the unknown. To also garner Musa's understanding of link-making, I asked him to provide a general idea of how he executed linking in his classroom. Musa replied that he executed linking in his classroom by using questions and using learners' answers to further elaborate or to clear any misconceptions. Here, Musa's knowledge of strategies that can be best utilised to aid learning and his use of those strategies (as can be seen in Table 4.1) reflects his PCK.

4.4.2 Teaching experience

In chapters One, Two and Three, it was mentioned that the CAPS document requires teachers to make links in their classrooms, between topics, between grades and between Natural Sciences and Life Sciences. As can be seen in Table 4.1, Musa rarely made links between different parts of the school curriculum, especially between the Natural Sciences content discussed in Grade Eight and Nine and the Grade Ten Life Sciences content. As such, Musa was questioned regarding his rare linking of Natural Sciences content and Grade Ten content. Musa responded,

> *Okay, there is linking. It is just that I don't mention that. What, what is that, that you did in Grade Eight or Grade Nine? Scared that they will, they will have a divided attention in what they will, they will have a divided attention in what I'm teaching. In the lesson I mentioned transporters, which is entailed in digestion gridlock. I mentioned carbon dioxide and oxygen, gaseous exchange rate, as well as Grade Nine energy to be transported. Grade Eight, respiration. So, I don't know to mention the grade. If I don't mention the grade, then the kids will focus. In fact, I was waiting for the… when I did the summary of the whole chapter is then that you tell them in Grade Eight is what you did. Indeed, seeing that, they have seen that in what? In the circulation. But to mention it when teaching. Then it will make a divided attention do you get it.*

Musa's response displays his teaching experience as an influential factor i.e., he stated that explicitly mentioning grades divides the attention of the learners and he instead mentions the link between Grade Ten and its prior grades when the entire chapter is concluded. This researcher gleaned experience as influential because such knowledge such as 'it divides learners' attention' can mostly be acquired through actual practice, and mainly because Musa only poses the minimum required qualification to teach with and is padded vast years of teaching experience.

4.4.3 Learners' interest and abilities

As can be seen in Table 4.1, Musa utilised one analogy, likening the circulatory system to the road transportation system, multiple times in his second lesson. His use of the analogy was exceptional, such that it prompted this researcher to enquire into it. When asked to explain why he utilised the analogy multiple times in his second lesson, Musa responded that,

> *These learners at their stage they have a short attention span. So, you had to make record, speak of something, associate something with the terminology that you about to take. Listen, I know whenever I say the highway, the mind is activated. Then I associated it with what the main blood vessels, the arteries, and the veins. You get it? And I have to make use of national rules that one that comes from the lead to the highway. So, whenever I'm going to ask them a question about the atrial small arteries and venules, small veins that it will bring up. By the way he said national road. Then it comes, then you go down, you cascade down. Then the byways. The byways are now what the vein was getting small veins and small the arterioles that form that particular.*

His utterances 'they have a short attention span' along with 'you had to make the record, speak of something, associate something with the terminology' showed that his Grade Ten Life Sciences learners' ability to maintain attention and to continue being interested in the blood vessels drove his decision to use this analogy in the lesson that focused on the components of the circulatory system. It would be remiss here to omit that Musa's responses, particularly the utterances that showed his learners' abilities and interests, also reflected his PCK (as presented earlier on) along with his teaching experience as underlying factors that also influenced his use of the analogy to teach the blood vessels of the circulatory system.

This factor, learners' interests, and abilities, also features later in Musa's interview. Here, Musa was asked to provide an explanation as to why he so frequently used incomplete sentences to teach rather than direct and explicit questions (see turn 67, line 3 in Excerpt 4.2). This question was posed to Musa, to determine why incomplete sentences were more utilised to get responses from learners rather than direct questions, as literal initiators were also vastly utilised by Musa (second to initiations that are used to provide information). Musa responded by stating that,

> *Yes, that is, to draw their attention and to see as to whether they are involved in the lesson. By making them complete the sentence, then they are with you, they are involved in your lesson.*

His response, attributes this particular use of the literal initiator as a way to seek the attention of his learners and also as a manner of ascertaining his learners' involvement in the lesson. Musa's response leads back to his learners' ability to maintain interest as influential to the talk moves, he utilised in his lesson sequence.

4.4.4 Nature of Life Sciences (the subject)

Another factor that emerged from the narratives Musa expressed was the nature of the subject. When this researcher asked Musa to share his reasoning for using direct questions (literal initiators) and then replying to them as a way to relay new information, particularly new terms, during his lessons he replied that,

> *Life Science is full of terminology. And hence you do have what we do have classrooms, class exercises, where I especially did with the terminology,*

because without understanding the terminology, they cannot understand their content. That is why I posit every question and answer myself.

Musa in his response relays that the nature of the subject of focus in this study, Life Sciences, dictates his use of literal initiators that he further responds to himself. He does this by justifying his particular use of the direct questions by highlighting the vast number of terms that are used and introduced in Life Sciences, thereby revealing the terminology-filled nature of the subject as an influential factor.

4.4.5 Learners' prior knowledge

When Musa was explicitly asked whether there were any factors that influenced his making of a certain link, he replied,

Most of my lessons I rely on question. The questions guide me as to whether they know much that I should not get much into the link, or they know less than I go in depth to the link.

His response exhibited his reliance on question as a measure of what learners know or do not know and how he should proceed in his teaching. Here, Musa's response does not just point at his Grade 10 learners' prior knowledge as an influencing factor in the making of pedagogical links, but also highlights the cruciality of the relationship between talk moves and the making of links. This is attributed to his statements that he uses questions to gauge the prior knowledge of learners so that he can make pedagogical decisions on whether he should further explore a pedagogical link with the learners or whether he should just stop at merely making the link.

4.4.6. Learners' Life Sciences language competencies

When he was asked to share on any other factors that influenced his link-making and the way in which he used talk to help his learners make those links, Musa replied, *The way they explain tends to terminology. I do allow them to explain in a street language. You get it? And then translate it into a biological term.*

In his response, Musa relays his learners' use of street language as a factor that drives him to link those street (colloquial) terms to their scientific counterpart. This was seen in one of lessons where he allowed learners to use the term 'backbone' and he then linked it to its scientific counterpart 'vertebral column' (see excerpt 4.3). His actions in excerpt 4.3 and his response here, reveal the learners' competencies to use the Life Sciences language as an influential factor in Musa's link-making.

4.5 Chapter summary

Musa used nine of the ten pedagogical link types, to promote continuity and support the building of knowledge. The only link not utilised was the connecting consecutive activities pedagogical link. The using different forms of representation pedagogical link was the most used in Musa's lesson sequence. The provides information initiating teacher talk move was the most frequently used in the promoting of all the pedagogical links that were utilised by Musa. The factors identified to have an influence of Musa's use of PLM and TTMs include Musa's PCK, Musa's teaching experience, learners' interests and abilities, the nature of Life Sciences (the subject), learners' prior knowledge and learners' Life Sciences language competencies.

CHAPTER 5: DATA PRESENTATION AND DATA ANALYSIS FOR THE SECOND CASE STUDY

5.1 Chapter introduction

The previous chapter presented the findings from the first case study. In this chapter, I present findings regarding the second case, Katlego, by presenting and elaborating more on the pedagogical links he promoted, followed by the teacher talk moves (TTMs) used to promote the identified pedagogical links. Thereafter, identified factors that may have been deciding factors in Katlego's use of pedagogical links and TTMs are presented.

5.2 Pedagogical links identified in Katlego's lessons

This section presents the pedagogical links made by Katlego. Table 5.1 shows the frequency of pedagogical links made by Katlego during the lessons.

Table 5.1: Table illustrating the pedagogical links that were promoted in each of Katlego's lessons

PLM form	Pedagogical link made	Frequency of link made per lesson			Frequency of links made in the lesson sequence
		Lesson 1	Lesson 2	Lesson 3	
		Focus: Flow of energy and trophic levels	Focus: Organisms' adaptations to the environment, food webs and food chains	Focus: Consolidation of food webs and food chains	
To support the building of knowledge	Use of analogies	-	-	-	-
	Using different forms of representation	20	31	4	55
	Using different scales and levels of explaining	11	7	1	19
	Connecting real-life occurrences with scientific explanations	1	5	-	6
	Connecting every day and scientific ways of explaining	3	14	1	18
	Connecting different scientific concepts to each other	2	5	-	7
To promote continuity	Connecting various points within a lesson	1	2	-	3
	Connecting various points within a lesson sequence	2	1	1	4
	Referring to different points in different parts of the science curriculum	1	-	-	1
	Connecting consecutive activities within a lesson	3	14	1	18

In terms of the first PLM form to support the building of knowledge, Table 5.1 displays using different forms of representation pedagogical link as the most promoted pedagogical link by Katlego, especially in the first and second lesson. This pedagogical link, as can be seen in Table 5.1, is also the most promoted pedagogical link in each of Katlego's individual lessons. This is followed by using different scales and levels of representation promoted mostly in the first lesson, as well as connecting consecutive activities within a lesson promoted mostly in in the second lesson. The least promoted link refers to different points in different parts of the science curriculum. Analogies were not promoted at all. What is interesting to note is that Katlego was able to promote links by connecting real-life occurrences to scientific explanations and by connecting different scientific concepts to each other in Lessons 1 and 2, but could not promote any of these two links in his third lesson.

In terms of the PLM form to promote continuity Table 5.1, present the connecting consecutive activities within a lesson pedagogical link as the most promoted continuity promoting pedagogical link in each of Katlego's lessons, and within the entire lesson sequence as well. The other pedagogical link used to promote continuity, which was also utilised in abundance, as far as the continuity pedagogical links in Katlego's lesson sequence is concerned, was connecting various points within a lesson sequence. Katlego promoted almost all the pedagogical links, which were coded for (see Table 3.3 in Chapter 3) with the exception of using analogies, in the observed lesson sequence. Now that the pedagogical links promoted by Katlego are documented, the following section presents the TTMs, which were utilised in the promoting of these links.

5.2 The teacher talk moves used by Katlego to promote the identified pedagogical links

This section presents the teacher talk moves utilised by Katlego to promote pedagogical links, presented in the previous section, using tables and lesson excerpts. I commence by presenting the promoted pedagogical links and her TTMs in a single table in order to illustrate where the TTMs were utilised and how often they were utilised by Katlego in her lesson sequence.

Table 5.2: A table displaying the frequency of TTMs used to promote various pedagogical links in Katlego's lesson sequence

PLM form	Pedagogical links	Lesson number and focus	Teacher Talk moves used					
			LAIM	LIIM	PIIM	RRM	URM	CRM
PLM form to support the building of knowledge	Using different forms of representations	1: Flow of energy and trophic levels	-	-	20	-	-	-
		2: Organisms' adaptations to the environment, food webs and food chains	-	-	27	-	-	-
		3: Consolidation of food webs and food chains	-	-	4	-	-	1
	Using different scales and levels of explaining	1: Flow of energy and trophic levels	-	1	10	1	-	-
		2: Organisms' adaptations to the environment, food webs and food chains	-	-	7	-	-	-
		3: Consolidation of food webs and food chains	-	-	1	-	-	-
	Connecting every day and scientific explanations	1: Flow of energy and trophic levels	-	1	6	-	-	-
		2: Organisms' adaptations to the environment, food webs and food chains	-	-	13	1	1	1
		3: Consolidation of food webs and food chains	-	-	1	-	-	-
	Connecting different scientific concepts to each other	1: Flow of energy and trophic levels	-	-	-	2	-	-
		2: Organisms' adaptations to the environment, food webs and food chains	-	-	5	-	-	-
		3: Consolidation of food webs and food chains	-	-	-	-	-	-
	Using analogies	1: Flow of energy and trophic levels	-	-	-	-	-	-
		2: Organisms' adaptations to the environment, food webs and food chains	-	-	-	-	-	-
		3: Consolidation of food webs and food chains	-	-	-	-	-	-
		1: Flow of energy and trophic levels	-	1	1	-	-	-

	Connecting real-life occurrences with scientific explanations	2: Organisms' adaptations to the environment, food webs and food chains	-	-	4	-	-	-
		3: Consolidation of food webs and food chains	-	-	-	-	-	-
PLM form to promote continuity	Connecting various points within a lesson	1: Flow of energy and trophic levels	-	1	1	-	-	-
		2: 2: Organisms' adaptations to the environment, food webs and food chains	-	-	2	-	-	-
		3: Consolidation of food webs and food chains	-	-	-	-	-	-
	Connecting various points in a lesson sequence	1: Flow of energy and trophic levels	1	2	-	1	-	-
		2: Organisms' adaptations to the environment, food webs and food chains	-	-	1	-	-	-
		3: Consolidation of food webs and food chains	-	-	1	-	-	1
	Referring to different teaching and learning points within different parts of the science curriculum	1: Flow of energy and trophic levels	-	-	1	-	-	-
		2: Organisms' adaptations to the environment, food webs and food chains	-	-	-	-	-	-
		3: Consolidation of food webs and food chains	-	-	-	-	-	-
	Connecting consecutive activities within a lesson	1: Flow of energy and trophic levels	-	-	3	-	-	-
		2: Organisms' adaptations to the environment, food webs and food chains	8	12	2	-	-	-
		3: Consolidation of food webs and food chains	2	1	-	-	-	-

As can be seen in Table 5.2 above, the PIIM was the most utilised move by Katlego in the promoting of all the nine identified links. This initiator was mainly used by Katlego in her first lesson that focused on the trophic elves and energy flow in ecosystems. The LIIM was also used by Katlego in the promoting of six of the pedagogical link types (using different scales and levels of explaining; connecting every day and scientific explanations; connecting real-life occurrences with scientific explanations; connecting various points within a lesson; connecting various points in a lesson sequence; along with connecting consecutive activities within a lesson), making it the second most utilised TTM by Katlego. The literal initiators were also used by Katlego, mostly in her first lesson as well. Initiating TTMs were the mainly used TTMs by Katlego in the promotion of all the pedagogical links identified in the previous section (see Table 5.2). What is interesting is that these initiators were mainly utilised in Katlego's first lesson and rarely utilised in the other lessons in her lesson sequence. Rejoinder TTMs were either not utilised or only utilised once by Katlego to promote all the identified pedagogical links i.e., they were all utilised in the promoting of a single pedagogical link. The LAIM is the least utilised initiating TTM as it was only utilised to promote two pedagogical links, illustrating that the launch initiator along with the rejoinder moves were the least utilised moves in the promoting of all the pedagogical links made by Katlego in their lesson sequence.

I present four excerpts below to illustrate how TTMs were utilised by Katlego to promote the most promoted pedagogical links as presented in the previous section. I start off by presenting an excerpt that illustrates how TTMs were utilised to promote the using different forms of representation pedagogical link. This excerpt is taken from

Katlego's second lesson, where Katlego was explaining how to calculate the percentage of the energy passed between trophic levels.

Excerpt 5.1: An example of how Katlego used talk moves to promote links between different forms of representation

Turn		Transcript
52	Learners	They break down dead bodies.
53	Katlego	They break down the dead bodies of pants and animals and return nutrients back to the soil and atmosphere. Dead organic material. And then back to 3.5. consider the energy flow in the food chain. We've got 97 000 kilojoules of grass, grasshopper 7000 and owl 50k. then you say to calculate the percentage of the energy that is passed on from the grass to the blue jay. Show all calculations from the grasshopper to the blue jay. We are going to divide them. We want percentage increase. The percentage of the energy that is passed. Two digits of after the comma [writes answer on whiteboard 8, 5]. The energy pyramid of the food chain, showed in 3.5. The energy pyramid will look like something like this [draws it on board]. This grass, grasshopper, blue jay and then owl…

Preceding this excerpt, Katlego was marking questions that the learners were provided in the lesson prior and was going through what decomposers are, which the learners provided an answer to in turn 52. Katlego in turn 53 starts by repeating the answer that the learners provided. By repeating the learners' answer, Katlego used the repeat rejoinder TTM. In turn 53, Katlego then verbalises the question which the learners were supposed to answer in the activity, thereby utilising a literal initiating TTM. Katlego then verbalises the process of calculating the percentage of the energy passed between the trophic levels and then writes only the answer on the board. This provides information initiating move is used to verbalise the process of calculating and by writing the answer on the board after stating how many decimal places to which learners should round their answer off, thereafter promoting the using different forms of representation pedagogical link. Katlego then proceeds to outline how the food web for the question provided would have looked and draws it on the board. By outlining verbally how the food web ought to look while drawing it on the board, Katlego utilises the information providing initiating move to make a link between spoken word and written word.

In summary, Katlego used the repeat rejoinder to acknowledge a learners' answer. She then used a literal initiating move to ask learners a question. Katlego then used the information providing initiating move to link the different representations of calculating energy passed between trophic levels. She finally used the information providing initiating move to link the different representations of a food web.

In the second example, I present an excerpt that illustrates how TTMs were utilised to connect every day and scientific explanations. This excerpt is taken from Katlego's first lesson. The focus of the lesson is on the concepts of plants as producers.

Excerpt 5.2: An example of how Katlego used moves to connect everyday and scientific explanations

Turn		Transcript
15	Katlego	You'll never know the number of cells that you have. But those cells, they play a very, very, very important role in your life. Now, there must be absorption of water, there must be absorption of food and so on. It's also for respiration through mitochondria. Now, animals feed on plants directly and indirectly so that you can put energy there. They are saying animals, they…they feed on plants directly and indirectly. We have animals like cow. They eat plants directly. Right? Now there are animals that eat plants indirectly. For example, the cow will eat the plants. Okay, then you get energy from the plant. Now another animal will feed on that animal. So, it's getting energy indirectly from the other animal. Animals like plants, also use food and energy for growth, production of organic compound and other activities. However, animals use more energy for the activities since they are more active. Since there are many more plants than animals. Plants can trap and store sufficient energy and not only for their own use, but also for the use of animals. Energy is passed on from the sun to the plants. The different level of animals it is, it is first transfer to the herbivores, or omnivores, and to the lower-level carnivore, and then the higher carnivore. When plants and animals die, the decomposers break up the dead bodies and recycle the energy back into the nature. This is called energy flow. That is what we're talking about today. It's the energy flow here [writes it on white board], we have plants [writes plants on the whiteboard]. There is nothing in this world that is more than plants. Plants are many compared to animals. We have more plants than animals, do plants buy food?
16	Learners	No.
17	Katlego	They don't. they do what? They are producers because they produce their own food. Through what?

Prior to this excerpt, Katlego discussed the sun as the main energy source and discussed how the energy from the sun reaches plants to set them up as producers. In turn 15, Katlego uses the points made in the preceding turns to show where plants get their energy and also where animals get their energy. Katlego then uses that to show learners why energy is required in plants and animals and where that energy is utilised. Katlego then discusses the flow of energy and the types of organisms one can find at the different energy levels. To this point Katlego has utilised only provides information initiating TTMs. The term energy flow is verbalised and is then written on the board by Katlego, after which Katlego also verbalises that there are plants and writes it on the board, before telling learners that plants are more abundant than animals. Katlego here utilises the provides information initiating TTMs to make connections between spoken word and written text, as well as to make the point that there are more plants than animals. After that, Katlego proceeded to ask learners whether plants made their way to stores to purchase food and the learners replied 'no' in turn 16. In turn 17, Katlego repeats the learners' answer that plants do not purchase their own food and then proceeds to utilise this answer to make a point that it is because the plants are able to make their own food that makes them producers. Katlego attempted to get learners to understand plants as producers by using a literal initiating TTM to ask the learners whether plants bought their food. Katlego's repetition of the learners' answers indicates the use of a repeat rejoinder TTM and then uses that answer to connect this idea of a plant not going to the store to purchase food to their idea of a plants as producer, thereby using a connection rejoinder TTM. Here, Katlego taught the concept of plants as producers against the everyday backdrop of never seeing plants 'walk' into a store to purchase food, thereby linking an everyday and a scientific way of explaining with the aid of the provides information initiator, literal initiator, repeat rejoinder, and connection rejoinder.

In summary, Katlego used moves that provide information to show learners where plants and animals get their energy, in order to show the vitality of energy and how it is utilised as well as to discusses the flow of energy and the organisms found in the various trophic levels. She then used the information providing move to link the various forms of representing energy flow. Katlego then used the literal initiating move, repeat rejoinder to ask learners whether plants made their own, to acknowledge the learners' answer and to use that answer to make a point.

In the third example, I present an excerpt that illustrates how TTMs were utilised to connect consecutive activities within a lesson. This excerpt is taken from the second lesson of Katlego's lesson sequence, whereby numerous questions were being answered.

Excerpt 5.3: An example of how Katlego used the provides information initiator to connect consecutive activities within a lesson

Turn		Transcript
11	Katlego	Respiration through gills, right? Yes. Here gills absorb oxygen from the water. They also have slimy scales to reduce the resistance to water. So, anything you have written. Number five, explain how, 5.1., animals are protected from the ultraviolet rays of the sun. How are they protected? So, it says 5.1. explain how animals are protected from the ultraviolet of the sun. Learner B?
12	Learner B	They are protected by the ozone layer
13	Learner C	Some animals produce sunscreen for themselves

In the turns preceding this excerpt, Katlego and the learners were discussing adaptations of animals to live in water in response to a question that is being reviewed. In turn 11, Katlego repeats an answer that a learner provided, thereby weaving interaction by utilising a repeat rejoinder; although not to promote a particular pedagogical link. Katlego then proceeds to discuss other adaptations animals have in order to live in water, thereby utilising the provides information initiator, although not at once promoting a particular pedagogical link. Further in turn 11, Katlego mentions the question number 5.1. prior to elaborating on the question denoted as 5.1. Here, Katlego utilises a provides information initiator to transition from the one part of the lesson to the next i.e., from animal adaptations to live in water to how animals are protected from the ultraviolet ray of the sun. The provision of scientific information ensured order in the working of the lesson, and thus connected the various activities of this lesson.

In summary, Katlego used a repeat rejoinder to acknowledge a learner's answer and then used an information providing move to present learner with additional facts. She then used an information providing move to connect consecutive activities within a lesson.

In the fourth and last example, I present an excerpt that illustrates how TTMs were utilised to connect consecutive activities within a lesson. This excerpt features a continuation of Katlego's first lesson. The focus of this particular part of her first lesson was the discussion of the different trophic levels that made up a food chain.

Excerpt 5.4: An example of how Katlego used initiators to move between different scales and levels of explanation.

Turn		Transcript
26	Katlego	Why is it less? It's going to be there because already the cow has used some of their activity. So, when you feed on that cow, it has lesser energy from what it got from the plant and so on. And then our last trophical level, we have decomposers. [writes it on whiteboard]. We spoke about decomposers, microorganisms, those smaller things that you cannot see with our eyes. They are here [gestures at the air]. They are everywhere. Sometimes they are called the germs. Some, they are here to help with decomposition, decomposition means '*ho bola*' [Sepedi for 'decomposition'] decay. Now, the flow of energy may be by means of food chain, food programming, food chains and food webs. The food chain is a path taken by energy that flows directly from one organism to another. It's called a food chain. The example will show the simple food chain in a grass land. We have plants and an arrow [writes it on the whiteboard; writes the rest of the food chain with the learners]. We have what? Remember the last time? We make energy flow from?

In turn 26, Katlego moves from the phenomenological level of food chain by explaining what it is and by going through a grassland example of a food chain, to explaining it on a symbolic level by representing the chain pictorially in the form of a flow diagram. To do this, Katlego utilises TTMs. The beginning of turn 26 starts with Katlego asking a question and then proceeding to answer it by explaining how energy decreases from level to level. By doing this, Katlego's use of a question shows the utilisation of the literal initiator and by answering that question by means of an explanation, Katlego utilises the provides information initiator. After that, Katlego then starts to speak about the decomposers and then writes the decomposers on the board. Here, Katlego utilised information providing initiating move to make a link between the spoken word and the written text on the board. Katlego then proceeds to explain what decomposers are and then uses hand gestures (see Figure 5.1) to show that microorganisms, some of which form decomposers, are found in the air. Here, Katlego utilises the provides information initiator in order to connect the physical space to spoken word. Katlego then proceeds to explain what decomposition is using the Sepedi language term '*ho bola'*, thus utilising the provides information initiator to use different forms of representation of the term decomposition. After that, Katlego then moves to verbally discuss what a food chain is (by providing information) and then proceeds to also to draw a pictorial representation of a food chain thus using different scales and levels of explaining. Simultaneously, Katlego moves from phenomenological and symbolic level. Here, Katlego moves between different levels (macroscopic and symbolic) of explaining a food chain with the aid of literal initiators and provides information initiators.

Figure 5.1: A screengrab of Katlego using hand gestures to make a pedagogical link

In summary, Katlego used a literal initiating move and an information proving move to discuss the energy loss between trophic levels. She then used an information providing move to link different representations of decomposers. Katlego then used an information providing move to link the different representations and to move between level of explaining food chains.

As can be seen in Table 5.2, the provides information initiating TTM is the most utilised TTM in the promotion of the identified pedagogical links and the least utilised was the launch initiating TTM. This pattern mirrors the one that was presented in Musa's findings chapter as well. The reasoning for the use of these TTMs and pedagogical links was not evident in the observed lessons, however an interview was conducted with Katlego to determine that reasoning.

5.4 The factors that influenced Katlego's use of TTMs to promote pedagogical link-making

As already mentioned in Chapter 4, this study argues that science teachers did not simply arrive at, rather made conscious or subconscious decisions regarding their pedagogical approaches (Ambusaidi & Al-Maqbali, 2022; McGinnis, 1998; Prachagool et al., 2016; Skeriene & Augustiniene, 2018; Waltzer, 2023). This also applies to using TTMs to promote pedagogical links in science classrooms. However, decisions are influenced by certain factors and as such sought them out. In this section, the study presents the factors that influenced Musa to make certain pedagogical links and to use particular TTMs. For this, it uses excerpts from the interview transcript of the interview conducted with Katlego. It presents these narratively owing to the nature of data analysis described in Chapter 3.

5.4.1 Teacher's PCK

Due to the link made by connecting every day and scientific explanations being used in a greater abundance (see Table 5.1), I asked Katlego whether there was any rationale behind her great use of this pedagogical link. Katlego replied that,

> *Normally kids, they relate to what they know. So, in order to make them understand, you must give them something that they can see or something they relate to.*

Numerous phrases in Katlego's responses reflect her pedagogical content knowledge (PCK). These phrases involve 'normally kids, they relate to what they know' and 'you must give them something that they can see or something they relate to.' In Chapter Two, PCK was defined as the teacher's ability to know the teaching strategies that are best suited to aid learners' understanding and using them (Schiering et al., 2023). Prior to being questioned on her frequent linking of everyday and scientific explanations, Katlego was requested to share her thinking when she heard the term 'linking'. Katlego replied that, to her, the term linking refer to linking whatever concept with real-life situations or anything that the learners could understand. To also garner Katlego's understanding of link-making, this researcher requested her to further provide a general idea of how she executed linking in her classroom. Katlego replied that she executed linking by linking current lessons with previous lessons as a way to display continuation. She also mentioned that she executed linking by using real-life experiences or things learners can relate to or can see. Here, Katlego's knowledge of strategies that can be best utilised to aid learning and her utilisation of those strategies (as can be seen in Table 5.1) reflects her PCK as a factor.

5.4.2 Learners' context

When Katlego was questioned on her abundant use of the link made by connecting every day and scientific explanations, she replied that,

> *Because I thought you can't just mention fox, some kids have never seen a fox in their life. So, it's very difficult for them to comprehend what is a fox? What is*

it? That is what it is. But the minute you mentioned something they are familiar with, it kind of makes sense to them.

Katlego's responses, particularly the phrases 'some kids have never seen a fox in their life' and 'the minute you mentioned something you are familiar with, it kind of makes sense to them' reveal the context in which the learners live in as an influencing factor too. This illustrates that Katlego is aware of her teaching context, and this influences how she utilises talk moves to promote links in her classroom, especially connecting every day and scientific terminology/explanations.

5.4.3 Learners' Life Sciences competencies

When Katlego was asked to share the rationale behind her simultaneous use of both Life Sciences terms (in English/ Latin) and Sepedi terms, in an attempt to garner into her peculiar move between different scales and levels of representation to make links, Katlego replies:

In the classroom, we have kids using different languages. So, home language is. That is the first reference of language that I refer to. Now, what I normally do is I would ask a certain term, and if I see that they are finding it difficult to understand it, then I would translate it to my home language, what do we call it in Zulu? What do you call it so that they can… they're able to relate to that and understand exactly what I'm talking about. Because Life Sciences use so many terminologies that, especially at Grade 10 level, its foundation phase, where they need to learn these things. Some this… these word are new to them. Some are very difficult to comprehend. So, it's just trying to make it easier for them so that they could not get lost. I do that every time I see that they are completely lost.

Her use of these phrases 'different types of language… so many terminologies… some are very difficult to comprehend' reveals her learners' Life Sciences competencies as influential in her use of talk moves to make links. In essence, her decisions on utilising certain moves are based on whether learners can be anticipated to handle the terminology or not. This ties also with the factor of being cognisant of the context of teaching.

5.4.4 Teacher's personal preferences

Due to her high use of different forms of representations to make links (see Table 5.1), Katlego was requested by this researcher to elaborate on her occasional writing on the whiteboard and her regular use of the Life Sciences textbook. Katlego replied that,

> *Okay, I personally do not prefer writing on the board. I really do not prefer. I just do not write… like writing on the board.*

When she was also requested to elaborate on her use of literal initiators in her lessons, she responded that,

> *I don't believe in everything at once. I prefer mini assessments.*

Her responses to the posed questions reflected her own personal preferences as an influencing factor. Her personal preferences can be attributed to how she was trained as well as other contextual factors like teaching context and experience.

5.4.5 Subject advisors/ facilitators

Remaining on the question directed to Katlego regarding her minimal whiteboard use and frequent textbook usage. Katlego also replied,

> *During our training, our facilitator will always tell us, you cannot be writing what is in the textbook. It's already there in the textbook. They can see it and they can see pictures if needs be.*

Here, Katlego explicitly names her Life Sciences subject advisor, also known as a subject facilitator, as an influencing factor. This means that the workshops that they usually have regarding teaching Life Sciences had an impact in terms of how she constructs her practice of using talk moves to promote links.

5.4.6 Resource availability

This researcher realised that, although Katlego mostly made the link between different forms of representations, she did not however use the digital interactive smartboard placed in her classroom. As a result, Katlego was requested to elaborate on her non-use of the digital interactive smartboard, she replied,

> *But then also, it's a matter of lack of resources. You know that our smartboards are not functioning, even in class, if you notice, it's very dark, we don't have electricity. So, it comes down to a matter of resources at times.*

Similarly to the previous sub-section, Katlego here also explicitly mentions a factor that influences the use of talk moves to make links, which in this sub-section is the availability of resources.

5.4.7 Nature of Life Sciences content

Another factor that emerged from the narratives that Katlego expressed was the nature of the Life Sciences content being dealt with. This was also garnered when this researcher asked Katlego to elaborate more on her use of the textbook and her occasional use of the whiteboard, where she replied that,

> *It also depends on the topic that we are handling. But if it requires practical examples, such as maybe like soil types, for example, that's when we bring actual solid and do the actual experiment.*

In the extract above, Katlego notices that different Life Sciences topics present themselves with a variety of challenges. For her, topics like soil types would require practical examples and representations. However, even in topics like circulatory system, teachers can use representations like concrete material to support talk moves used to promote links.

5.4.8 Learners' attention span

Similar to Musa, Katlego also talked about the role of understanding learners as a factor in using talk moves to promote links. However, for her, it was about learners' attention span. In the interview, Katlego narrated that,

> *I'm trying to explain whatever it is as possible as I can or maybe trying to make picture of it if it makes sense. But yeah, I don't know. I wouldn't say it's a habit, but I do that a lot when I teach because I try to bring. I'll be trying to bring a certain concept or draw attention to me… so, normally the using of hands will just draw their attention to me.*

This narration follows a question posed to her to attempt to find the rationale behind her use of hand gestures (a form of representation) during her lessons. Her response frequently mentions learners' attention, evidencing that these are influential.

5.4.9 Teacher's experience

Sometime in the interview, Katlego narrated that, 'again, I'm trying to attach it to me because kids do wonder at times and look outside and do this and that.' She narrates that in response to the question posed to her regarding her use of hand gestures while teaching. Her response reflects that she possesses some experience with dealing with learners and that her use of hand gestures may just be majorly influenced by her former interactions with learners (teaching experience).

5.4.10 Contextual factors

This researcher requested Katlego to share any factors that influenced her utilisation of talk moves to make links. Katlego replied that,

> *You know, normally, you could prepare a lesson and say, I'm going to do this. You prepare to go to class, but then when you get there, you find contextual issues that don't even relate to your… your content of teaching. You could also find out that maybe there is an issue that you need to address first. Maybe kids were fighting. Maybe this, maybe another learners is sick. A lot of things can happen at a moment.*

Here, the phrases 'kids were fighting' and 'learners is sick' reveal contextual factors as another influential factor in Katlego's use of talk moves to make links.

5.5 Chapter summary

Katlego promoted nine of the ten pedagogical link types to support the building of knowledge and to promote continuity. The only link not promoted was the usage of analogies pedagogical link. The using different forms of representation pedagogical link was the most promoted in Katlego's lesson sequence. The other pedagogical links that were promoted abundantly by Katlego after the different forms of representation are the using connecting every day and scientific explanations and connecting consecutive activities within a lesson pedagogical links. Pedagogical links that promote continuity were the least promoted in Katlego's lesson sequence. This provides information initiating teacher talk move was the most frequently used in the promoting of all the pedagogical links that were utilised by Katlego, where the launch initiating TTM was the least utilised. Initiating TTMs were utilised more than rejoinder TTMs to promote the pedagogical links promoted by Katlego. The factors identified to have an influence on Katlego's use of PLM and TTMs include Katlego's PCK, the learners' context, learners' Life Sciences competencies, Katlego's personal preferences, subject advisors/ facilitators, resource availability, nature of Life Sciences content, learners' attention span, Katlego's experience as well as contextual factors.

CHAPTER 6: DATA PRESENTATION AND DATA ANALYSIS FOR THE THIRD CASE STUDY

6.1 Chapter introduction

The previous chapter presented the findings from the second case study. The previous chapter presented and discussed the findings from the first case study. In this chapter, I present my findings regarding my third and last case, Peace. I start off by presenting and elaborating more on the pedagogical links he promoted. I then present the Teacher talk moves (TTMs) used to promote the identified pedagogical links. I finally present the identified factors that may have been deciding factors in Peace's use of pedagogical links and TTMs.

6.2 Pedagogical links identified in Peace's lessons

In this section, I present the pedagogical links made by Peace. Table 6.1 shows the frequency of pedagogical links made by Peace during the lessons.

Table 6.1: Table illustrating the pedagogical links that were promoted in each of Peace's lessons

PLM form	Pedagogical link made	Frequency of link made per lesson			Frequency of links made in the lesson sequence
		Lesson 1	Lesson 2	Lesson 3	
		Focus: Kingdom Plantae and Kingdom Animalia	Focus: Kingdom Protista and Kingdom Animalia	Focus: Organic compounds	
To support the building of knowledge	Use of analogies	-	-	-	-
	Using different forms of representation	58	11	30	99
	Using different scales and levels of explaining	7	1	15	23
	Connecting real-life occurrences with scientific explanations	1	2	1	4
	Connecting every day and scientific ways of explaining	10	5	11	26
	Connecting different scientific concepts to each other	10	6	9	25
To promote continuity	Connecting various points within a lesson	6	-	-	6
	Connecting various points within a lesson sequence	2	-	3	5
	Referring to different points in different parts of the science curriculum	2	1	1	4
	Connecting consecutive activities within a lesson	12	3	6	21

As can be seen in Table 6.1, Peace promoted the following pedagogical links in each of their lessons i.e., using different forms of representations; using different forms of representation; using different scales and levels of explaining; connecting real-life occurrences with scientific explanations; connecting every day and scientific ways of explaining; connecting different scientific concepts to each other; referring to different points in different parts of the science curriculum; as well as connecting consecutive activities within a lesson. Five of these seven pedagogical links fall under the PLM (pedagogical link-making) from to support the building of knowledge, thus reflecting the form to support the building of knowledge as the most utilised by Peace in all their lessons.

Peace promoted all the pedagogical links to promote continuity, however the connecting various points within a lesson pedagogical link was only promoted in a sole lesson and the connecting various points within a lesson sequence pedagogical link was promoted in two of the three lessons presented by Peace. The other links to promote continuity, although promoted in all of Peace's lessons, follow a trend similar with those presented prior to this in that they are promoted lesser than knowledge building pedagogical links. This indicates that peace promoted the PLM form the least to achieve continuity in her lessons.

The different forms of representation pedagogical link, as can be seen in Table 6.1, is also the most promoted pedagogical link in each of Peace's lessons. The two other pedagogical links promoted to support the building of knowledge which were promoted the most in descending order include the using every day and scientific ways of explaining, as well as using different scales and levels of explanation. These two above-mentioned pedagogical links, although in a variant order, are similar to those found in Musa's and Katlego's lessons.

Table 6.1, present the connecting consecutive activities within a lesson pedagogical link as the most promoted continuity promoting pedagogical link in each of Peace's lessons and within the entire lesson sequence as well. The other pedagogical link to promote continuity, which was also utilised in abundance, as far as the continuity pedagogical links in Peace's lesson sequence goes, is the connecting various points within a lesson pedagogical link. It is vital to note that, as much as the various points within a lesson pedagogical link was used in abundance overall, it was used in a single lesson, and not across all the lessons. The other pedagogical links to promote continuity i.e., various points within a lesson sequence along with the referring to different points in different parts of the science curriculum were utilised the least in the lesson sequence, but were present in almost every lesson presented by Peace.

6.3 The teacher talk moves used by Peace to promote the identified pedagogical links

In this section, I present the teacher talk moves utilised by Peace to promote pedagogical links, presented in the previous section. For this, I use tables and lesson excerpts. I start off by presenting the promoted pedagogical links and her TTMs in a single table to illustrate where the TTMs were utilised, and how often they were utilised by Peace in her lesson sequence.

Table 6.2: A table displaying the frequency of TTMs used to promote various pedagogical links in each of Peace's lessons

PLM form	Pedagogical links	Lesson number and focus	Teacher Talk moves used					
			LAIM	LIIM	PIIM	RRM	URM	CRM
PLM form to support the building of knowledge	Using different forms of representations	1: Kingdom Animalia and Kingdom Plantae	-	1	55	-	-	-
		2: Kingdom Protista and Kingdom Fungi	-	1	11	-	-	-
		3: Organic compounds	-	2	25	6	1	1
	Using different scales and levels of explaining	1: Kingdom Animalia and Kingdom Plantae	-	2	8	-	-	-
		2: Kingdom Protista and Kingdom Fungi	-	1	-	-	-	
		3: Organic compounds	-	11	7	1	1	2
	Connecting every day and scientific explanations	1: Kingdom Animalia and Kingdom Plantae	1	7	5	1	1	1
		2: Kingdom Protista and Kingdom Fungi	-	1	5	-	-	-
		3: Organic compounds	1	5	9	1	3	3
	Connecting different scientific concepts to each other	1: Kingdom Animalia and Kingdom Plantae	-	6	13	-	-	-
		2: Kingdom Protista and Kingdom Fungi	-	4	6	-	-	-
		3: Organic compounds	1	8	7	2	4	4
	Using analogies	1: Kingdom Animalia and Kingdom Plantae	-	-	-	-	-	-
		2: Kingdom Protista and Kingdom Fungi	-	-	-	-	-	-
		3: Organic compounds	-	-	-	-	-	-
	Connecting real-life occurrences with scientific explanations	1: Kingdom Animalia and Kingdom Plantae	-	-	2	-	-	-
		2: Kingdom Protista and Kingdom Fungi	-	1	2	-	-	-
		3: Organic compounds	1	1	1	-	-	-
PLM form to promote continuity	Connecting various points within a lesson	1: Kingdom Animalia and Kingdom Plantae	-	3	5	-	-	-
		2: Kingdom Protista and Kingdom Fungi	-	-	-	-	-	-
		3: Organic compounds	-	-	3	-	-	-

	Connecting various points in a lesson sequence	1: Kingdom Animalia and Kingdom Plantae	-	1	1	-	-	-
		2: Kingdom Protista and Kingdom Fungi	-	-	-	-	-	-
		3: Organic compounds	-	1	4	1	-	1
	Referring to different teaching and learning points within different parts of the science curriculum	1: Kingdom Animalia and Kingdom Plantae	-	1	5	-	-	-
		2: Kingdom Protista and Kingdom Fungi	-	-	1	-	-	-
		3: Organic compounds	-	-	1	-	-	-
	Connecting consecutive activities within a lesson	1: Kingdom Animalia and Kingdom Plantae	-	1	11	-	-	-
		2: Kingdom Protista and Kingdom Fungi	-	2	6	-	-	-
		3: Organic compounds	-	2	5	-	-	-
		TOTAL	4	62	198	12	10	12

As can be seen in Table 6.2, the provides information initiating move (PIIM) was the most utilised TTM by Peace in the promoting of all the nine identified links. This type of initiators was majorly used in Peace's first lesson, which focused on the Kingdoms Animalia and Plantae. The literal initiating move (LIIM) was also utilised by Peace in the promoting of all the identified pedagogical links, making it the second most utilised TTM by Peace. Literal initiators were abundantly utilised in Peace's second lesson, which focused on the Kingdoms Protista and Fungi. Initiating TTMs were the mainly used TTMs by Peace in the promoting of all the identified pedagogical links in the section before this (see table 6.2). Rejoinder TTMs were either not utilised, or utilised significantly less than the initiating TTMs to promote all the identified pedagogical links. That is, they were all utilised in the promoting of three pedagogical links all of which were knowledge building. The utilised rejoinders were mainly utilised in Peace's third lesson, which focused on organic compounds. The launch initiating move (LAIM) is the least utilised TTM as it was only utilised to promote five pedagogical links (which was higher than with Musa and Katlego). This illustrates that the LAIM was along with the rejoinder moves were the least utilised TTMs in the promoting of all the pedagogical links made by Peace in their lesson sequence.

I present four excerpts below to illustrate how Peace utilised TTMs to promote the most promoted pedagogical links as presented in the previous section. I start off by presenting an excerpt that illustrates how TTMs were utilised to link different forms of representation. This excerpt is taken from Peace's first lesson whereby Peace was elaborating more on the plant groups found in the plant kingdom.

Excerpt 6.1: An example of how Peace used initiating moves to link different forms of representation

Turn		Transcript
27	Peace	You call those one the adventitious roots. And then just above, you find the young fern leaf. It's not yet mature. Again. It's said to be young and then you get your mature compound. The reason why it's said to be compound, it's because they share branches again (draws on board), like, can you see that?
28	Learners	Yes.
29	Peace	So, a fern plant consists of compound leaves. There are many leaves on one stalk (indicates this by using hand gestures). Okay. General characteristics, number one, all the groups are said to be multicellular and… ?

Prior to this excerpt, Peace introduced the Kingdom Plantae and presented the plant groups found in the kingdom namely bryophytes, angiosperms, pteridophytes, and gymnosperms. The start of this excerpt still features examples of pteridophytes, which are ferns. In turn 27, Peace explains why fern leaves are said to be compound, by elaborating verbally that it is because they share a branch, and then further elaborates this pictorially by drawing on the board and then lastly utilises hand gestures in turn 29 to get the point of the compound leaf across. Here, Peace moved between three forms of representation i.e., verbal, pictorial and kinetic, in order to explain a compound leaf. To do so, Peace starts off by providing information for most of the duration of turn 27 as a means of delivering the piece of information that ferns are compound leaves and of connecting what they are saying to a pictorial presentation of a compound leaf. Peace then finally uses a literal initiator to ascertain whether learners are still following her explanation. In turn 29, Peace uses the provides information initiator to explain what a compound leaf is, and to connect it with how it may look by using hand gestures. Peace then ends this section of the lesson by directing learners to the general characteristics of all plant groups with the use of a question, thereby utilising the literal initiating TTM. Here, Peace is aided by the literal and the provision of information initiators to make links between the verbal, pictorial, and kinetic forms of representing a fern compound leaf.

In summary, Peace used an information providing move to link the different representations of ferns as compound leaves. She then used a literal initiating move to determine whether learners were following through with the lesson. Peace then used an information providing move to link the different representations of compound leaves. Finally, she used a literal initiating move to direct learners towards the characteristics of all plant groups.

In the second example, I present an excerpt that illustrates how moves were utilised to connect every day and scientific explanations. This excerpt is also taken from Peace's first lesson where Peace briefly discusses protists, particularly algae, in order to make a point of it being the common ancestor of green plants. The contents of this excerpt precedes those found in Excerpt 6.1.

Excerpt 6.2: An example of how Peace used initiators to connect every day and scientific explanations

Turn		**Transcript**
4	Peace	Guys let me tell an example, you know when you always open a tap near the wall, a plant grows there [all said in Sesotho], because it's always wet? That is what they are. Do you see that thing?
5	Learners	Yes.

Preceding this excerpt, Peace introduced the concept of algae as an autotrophic protist and proceeded to ask them whether they were familiar with or rather whether they knew what algae was. Some of the learners had an idea and some did not, and as such this excerpt features the moment where Peace attempts to explain what algae is to the Grade 10 learners. Peace in turn 4, starts by providing information to let the learners know about algae by relating it to what they see every day, and may have a different explanation for its development. Peace then uses a literal initiating TTM to determine whether the learners have at some point come across algae, before continuing with the rest of Kingdom Plantae. Here, Peace linked an everyday and a scientific explanation of what algae is with the aid of literal and provision of information initiators.

In summary, Peace used an information providing move to link every day and scientific explanations of what algae is. She then used a literal initiator to gather information on the learners' prior knowledge of algae.

In the third example, I present an excerpt that illustrates how talk moves were utilised to move between different levels and scales and levels of explaining. This excerpt is taken from Peace's third lesson, where Peace and the Grade 10 learners are discussing the carbohydrates as organic compounds.

Excerpt 6.3: An example of how Peace used the provides information initiator to move between different scales and levels of explaining

Turn		Transcript
69	Peace	There is a reason why I'm writing them this; it's because mono is actually the building blocks of all those two. So, I want use to see them properly [writes on board]. Its G, Ga, and L [writes them on the board one underneath the other). Then disaccharides… we are going to call them. We have three again, it's M, S…[writes them one underneath the other on the board].
70	Learners	L

The turn prior to these present with Excerpt 6.3, feature Peace asking the learners to elaborate on the types of carbohydrates we find and also features some of the learners' Reponses. In turn 69, whilst writing the list of monosaccharides, disaccharides, and polysaccharides, Peace explicitly provides the learners with reasoning as to why monosaccharides were listed first prior to disaccharides. Peace does this by using the information providing move, which was also used here to make multiple different forms of representation links. Peace reasons that the reason why monosaccharides are listed first on the board is because they are the building blocks of disaccharides and polysaccharides, thus utilising the provision of information move to promote the pedagogical link whereby different scales, symbolic and macroscopic, were utilised to explain.

In summary, Peace used an information providing move to link different representations of monosaccharides, disaccharides, and polysaccharides. She also used an information providing move to link different scales of carbohydrates.

In the fourth and last example, I present an excerpt that illustrates how moves were utilised to connect every day and scientific explanations. This excerpt is taken from Peace's second lesson where she briefly discusses the structure of fungi.

Excerpt 6.4: An example of how Peace used initiators to connect consecutive activities within a lesson

Turn		Transcript
26	Peace	They can give you that structure. Then they say to you identify the structure, it makes up which group, label the structure. They can remove a. maybe they write a, b, c. then they remove what the labelling. You need to be able to identify what is a, what is b, what is c. also know what their function. Can we go to the characteristics? Characteristics. Characteristics guys are important to know for examination. If we refer to unicellular as one, many we refer to be what?

Prior to this excerpt, Peace was discussing the structure of fungi that was provided on a set of notes provided by Peace to the learners. The start of this excerpt shows Peace utilising the provision of information initiating move to inform learners how the structure of fungi can be assessed in the exam. Peace then asks the learners 'can we go to the characteristics' after discussing the structure of fungi thus utilising the literal initiating move to transition from the one part of the lesson (structure of fungi) to the next (characteristics of fungi). This ensured order in the lesson and connected the various 'activities' within this lesson. Peace then proceeds to provide information in order to inform learners about the importance of the section they are about to start. This turn is then ended by Peace providing information in order to ask learners a question, thereby utilising both the provision of information and the literal initiators to connect consecutive activities within this lesson.

In summary, Peace used the information providing move to inform learners about exam requirements. She also used a literal initiating move to connect consecutive activities within a lesson. Peace then used an information providing move to emphasise the importance of the section that is about to be discussed. Finally, she used both a literal initiator and an information providing move to provide learners with information and ask then a follow-up question.

As can be seen in Table 6.2, the provision of information initiating move is the most utilised TTM in the promotion of the identified pedagogical links and the least utilised was the launch initiating TTM. This pattern here mirrors the one that was presented in Musa's and Katlego's findings chapter as well. The reasoning for the use of these TTMs and pedagogical links was not evident in the observed lessons, however an interview was conducted with Peace to determine that reasoning.

6.4 The factors that influenced Peace's use of TTMs to promote pedagogical link-making

As mentioned in Chapters 4 and 5, in this study I am taking the view that science teachers did not simply arrive at, rather made conscious or subconscious decisions regarding their pedagogical approaches (Ambusaidi & Al-Maqbali, 2022; McGinnis, 1998; Prachagool et al., 2016; Skeriene & Augustiniene, 2018; Waltzer, 2023). This also applies to using TTMs to promote pedagogical links in science classrooms. However, decisions are influenced by certain factors, and as such sought them out. In this section, I present the factors that influenced Peace to make certain pedagogical links and to use particular TTMs. For this, I use excerpts from the interview transcript of the interview conducted with Peace. I present these narratively owing to the nature of data analysis described in Chapter 3.

6.4.1 Learners' learning styles and preferences

Table 6.1 exhibited the link made by using different forms of representation as the most made pedagogical link by Peace. As a result, this researcher questioned Peace on her consistent use of the whiteboard and print-out notes. Peace replied, *Yeah, whiteboard is very important because you might teach learners. Sometimes learners cannot hear, let me not use hear, cannot actually grab what you are saying in classroom. So, you'll actually be writing notes for them to use as reference, so that they take those notes. At home, they will be relying on them to actually grab the content that you thought, because it's not every learner that learns from the talking.*

Here, the phrases 'sometimes a learner cannot hear…grab what you are saying in classroom' and 'it's not every learner that learns from the talking' by Peace reveals Peace's willingness to accommodate learners' various learning styles and the phrase 'writing notes for them to use a reference so that they take those notes' also reveals Peace's consideration of learners' learning preferences in her teaching. These imply learners' learning styles and learning preferences as influential factors.

6.4.2 Nature of Life Sciences (the subject) and the topic

The nature of content also seemed to be a factor for Peace. In the interview conducted with Peace, she narrated that,

Life Sciences is actually a reading subject, so you're not gonna teach without notes. You need to give them something that they will rely on. Read it so that it gives them a better understanding when you are using the whiteboard.

Her narration was uttered in response to a question posed to her by this researcher. The question was posed to determine why Peace utilised print-out notes that learners had to follow through alongside writing on the board. Peace's narration points to the theoretical nature of subject (Life Sciences) as a factor that influenced her use of talk moves to make pedagogical links.

Although Peace made links between different forms of representations, she did not utilise the digital interactive smartboard that is located in her classrooms. As such this researcher requested her to explain why she did not utilise the smartboard. Peace responded that,

> *It depends on the topic that you're teaching. Some topics you can never rely too much writing, rather give them photo copies because when you teach Life Sciences, we have structures, we have all that. So, I cannot draw structures on the board, but I rather use a black and white paper that is having everything and then I explain in case they want more of explanation. That is when I start using the whiteboard in order for them to have a clarity of something.*

She mentions that certain topics that feature structures would require photocopies, while certain topics require writing on the board; his explicitly refers to the nature of the topic as an influencing factor too.

6.4.3 Teacher's PCK

Due to her exceptional linking of real-world occurrences to scientific explanations, Peace was requested to elaborate on her making of links between real-world occurrences and scientific explanations. Peace elaborated that,

> *When you're giving learners examples that are based on their real-life situations, you're actually trying to show them that they are learning, its actually what they are learning. Normally I give them the real-life examples, because I want them to relate the content that they're learning to the real-life situations. This will give them a better understanding…so, you're actually trying to make them to recall…then this gives them an idea, oh, this topic.*

Peace's pedagogical content knowledge (PCK) is reflected by her elaboration that she uses real-life examples and situations in her classroom because it will provide learners with a better understanding. In the literature review chapter, PCK was defined as the teacher's ability to know the teaching strategies that are best suited to aid learners' understanding and using them (Schiering et al., 2023). Prior to being questioned on her linking of real-world occurrences to scientific explanations, Peace was requested to share what came to her mind when she heard the term 'linking'. Peace replied that, to her, the term 'linking' refers to the gradual movement from one grade to another and linking the subject content together. To also garner Peace's understanding of link-making, this researcher requested her to further provide a general idea of how she executed linking in her classroom. Peace replied that she executed linking by connecting topics to each other, and by linking various grades to each other. Here, Peace's knowledge of strategies that can be best utilised to aid learning and her utilisation of those strategies (as can be seen in Table 6.1) reflects her PCK as a factor.

6.4.4 Teacher's experience

Another factor that emerged from the narratives that Peace expressed was her teaching experience. This was garnered when this researcher questioned her on her making of links between Grade Eight and Grade Nine Natural Sciences content and the Grade 10 Life Sciences content and she replied that,

> *For me, normally when I link the subject, I just go to Grade Nine and then focus more on the coming grades, because I know that the content is going to be more detailed on the coming grades. Remember, when you go to Grade Eight and Nine, it's basically the foundation of the subject, which is learning science. So, more of the detailed content will be given on the upcoming grades. Hence, I do it.*

Her use of the term 'normally' along with the phrase 'I know that the content is going to be more detailed' reflect her teaching experience in Life Sciences as an influential factor.

6.4.5 Learners' abilities

When she was asked to elaborate on anything that may influence her link-making, Peace narrated that,

> *When I communicate every concept or the linking of every subject. I don't just start looking at the grades, how they link, but I firstly look at the type of language that I have, because every year, remember, you inherit different learners. So, you look at that capacity. You also need to know that you need to prepare them of what is coming.*

Here, her mention of inheriting different learners reveals learners' abilities as an influential factor in how she makes links in her Grade 10 Life Sciences classroom.

6.4.6 Learners' responses and questions

Peace narrated that,

> *Yeah, especially this happens when you are having classroom talks or classroom discussions and one learner pop out the question. Maybe then that is when you tend to switch from what you are doing. Then you go and elaborate more on what the learners is asking.*

This response was given when Peace was asked to share anything that influenced her defer from her lesson planning in order to either make more of a certain link or to make less of a certain link during classroom instruction. Her response points to questions that ask as the one thing that may cause her to defer from her planning.

This reveals learners' responses and questions as influential to the process using talk moves to make links.

6.4.7 Time

When she was requested to explicitly elaborate on the factors that influenced her use of talk moves to make links, Peace replied,

> *There's plenty of factors. Um, actually it might be the timetable on its own. You look at the time of the period may be given and then maybe sometimes you see that, oh, I'm having so much time left. Therefore, that is when you start saying, hey, let me change this and do this so that to cover this topic in that given time of the left time that you have. But sometimes we go to class late. Then this is when you will start planning. This won't be for the whole one hour. If I need to start preparing something fast for 30 minutes, that is when you leave what you are planning to do. So, as a teacher, you need to forever be prepared for anything.*

Her response shows time an influential factor and this can be seen in her use of the words 'timetable, time left, 30 minutes and whole one hour'.

6.5 Chapter summary

Peace promoted nine of the ten pedagogical link types, to support the building of knowledge and to promote continuity. The only link not promoted was the usage of analogies pedagogical link. The using different forms of representation pedagogical link was the most promoted in Peace's lesson sequence. The other pedagogical links promoted abundantly by Peace after the different forms of representation are the using connecting every day and scientific explanations and connecting consecutive activities within a lesson pedagogical links. Pedagogical links that promote the continuity were the least promoted in Peace's lesson sequence. This provides information initiating teacher talk move was the most frequently used in the promoting of all the pedagogical links that were utilised by Peace, and the launch initiating TTM was the least utilised. Initiating TTMs were utilised more than rejoinder TTMs to promote the pedagogical links promoted by Peace. The factors identified to have an influence on Peace's use of PLM and TTMs include learners' learning styles and preferences, the nature of Life Sciences (the subject), the nature of the topic, Peace's PCK, Peace's experience, learners' abilities, learners' responses, and questions along with time.

CHAPTER 7: DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

7.1 Chapter introduction

In this chapter, I discuss the findings presented in Chapters 4-6 and then proceed to address the research questions of this study. I then present the significance of this study and then procced to present the recommendations of this study. I end this chapter and this dissertation by presenting concluding remarks.

7.2 Discussion of findings

This study aimed to explore how Grade 10 Life Sciences teachers utilised teacher talk moves (TTMs) to promote pedagogical links. To be able to do this, the type of pedagogical links promoted, the TTMs utilised to promote those pedagogical links and the factors that influenced the use and promotion of those TTMs, and pedagogical links were sought out, analysed, and presented. In this discussion section, I put major findings from chapters 4-6 into discussion.

7.2.1 Pedagogical links observed in the teachers' classrooms

As can be seen in Table 4.1, Table 5.1 and Table 6.1, the most promoted link was using different forms of representations. This finding was not unexpected. In Chapter 2, certain aspects that were declared as integral in any science classroom were presented and representations featured as one of the four vital aspects presented and discussed. Representations were deemed a vital aspect because learners cannot mobilise any knowledge without them (Mainali, 2021). Kokkonen and Schalk (2021) stated that representations serve as surrogates to which teachers can off-load cognitive processing demands, with the aim of supporting reasoning and thinking, this was seen in Excerpt 4.1 and Figure 4.1. where Musa relied on his body to help the Grade 10 learners process naming the joint between the clavicle and humerus.

Excerpt 4.2 finds Musa pointing at a link diagram of how gases (oxygen and carbon dioxide) move in the circulatory system to the aid the learners to process the numerous terms associated with the circulatory system, and by extension, the pathway of blood in the circulatory system. This use of representations as cognitive off-load surrogates can also be seen in Excerpt 4.4., where Musa verbally discusses the nature of suture joints (a form of representation) and then proceeds to also write it on the board (another form of representation) to aid the thinking of learners. Similarly, Katlego and Peace also heavily utilise representations to aid the learners' thinking and reasoning. Excerpt 5.1 shows Katlego verbalising how to calculate the percentage of energy passed between trophic levels and states how many decimal places to round the answer off to (verbal representation) and then proceed to write it on the board (another form of representation). In so doing, Katlego simultaneously utilised two different forms of representation to off-load the cognitive processing demands of the learners. In Excerpt 5.4, Katlego gestures at the air to express or to aid the learners to get the gist of micro-organisms, thus aiding the thinking process of the learners by indicating at something they can 'see' to lead away from the abstract idea of micro-organisms. Peace also does the same in Excerpt 6.1 by initially explaining what a compound fern leaf is verbally (a form of representation) and then further pictorially by drawing it on the board (another form of representation) and then finally by suing hand gestures (another form of representation).

Besides being merely utilised as surrogates for cognitive off-loading, the representations as prior indicated were also utilised by Musa, Peace, and Katlego to capture the entirety of scientific concepts (Hansen & Richland, 2020), a notable one being Peace's explanation of a compound fern leaf. It was also stated in the literature review chapter, that the ideal way to effectively utilise representations by using not just one representation but multiple representations (Hausen & Richland, 2020; Kokkonen & Schalk, 2021; Munfaridah et al., 2021). All three of the Grade 10 Life Sciences teachers utilised more than one representation at a time, thereby implying that their lessons featured a greater level of accessibility to abstract and complex concepts and in extension enhanced the Grade 10 Life Sciences learners' learning (Munfaridah et al., 2021).

As also seen in Table 5.1 and Table 6.1, Katlego's and Peace's second most utilised pedagogical link was connecting every day and scientific ways of explaining, which was Musa's third most utilised pedagogical link, as can be seen in Table 4.1. Similarly to the different forms of representation link, this pedagogical link is also featured as one of the four vital aspects that were deemed integral in any science classroom (see sub-section 2.2.4.3 in Chapter 2). Tunnicliffe and Ueckert (2007), Watkins and Manz (2022) along with Zidny et al. (2021) argue for an instructional process of science to be based on societal situations and/or everyday events in order to enable learners to optimise gist and meaning. This is generally manifested as the relation of scientific and spontaneous concepts (Duran, 2018). A good depiction of this can be seen in Excerpt 6.2 where Peace describes algae as a green plant that is generally found around taps near walls in order to familiarise learners to the concept of algae as an autotrophic protozoan. Katlego in Excerpt 5.2 exhibits this pedagogical link and vital aspect by referring to an everyday event, such as purchasing food in order to get the learners to understand the notion of plants as producers and not consumers. Excerpt 4.3 displays Musa's use of the spontaneous concept 'backbone' to enable learners to understand the scientific term ‘vertebral column’. This also exhibits the use of the vital aspect of science being based on everyday events and/or societal events.

Margolis (2020) states that teachers should manufacture the necessary conditions that allow for learners’ spontaneous concepts to develop after mentioning that the formation of science concepts is done on the basis of the spontaneous concepts of learners and not outside them. The examples provided from Excerpts 4.3, 5.2 and 6.2 all display that the Grade 10 Life Sciences teachers did in fact manufacture the necessary conditions. An example of this the question of plants purchasing food at the store posed by Katlego in order to allow for the learners’ spontaneous concepts to develop. This is followed by exposing the learners to scientific concepts as a way to develop their spontaneous concepts. An example of this is Katlego’s then utilisation of the above-mentioned spontaneous concepts to aid learners to make meaning of plants as producers. This aspect basically links the learners’ everyday lives to scientific knowledge, and was introduced as a solution to solve a decades long struggle on the designing of instructional activities to balance the initial presentation of canonical events, with the making of science learning as personally relevant to the learners (Furberg and Silseth, 2020). This aspect was deemed vital as a solution vital because it can establish science classrooms as learning environments that are authentic, profound, and inclusive as argued in previous studies (Owens et al., 2020; Russell & Martin, 2023). Since this aspect is the second most present in Katlego’s and Peace’s and their third most present in Musa’s Grade 10 Life Sciences classrooms, it may be inferred that all three of the teachers made science learning relevant to the learners in their introduction and in extension paints the learning environment in the Grade 10 Life Sciences classrooms of Musa, Katlego, and Peace as authentic and inclusive. The learning environment assertion here can be seen in the original and context-specific examples utilised by these teachers e.g., Peace's use of green growth on walls found next to taps to refer to algae, instead of snow banks or rocks found in streams/ rivers, was authentic and inclusive, as Gauteng does not receive snow and the area around School A does not have streams or rivers.

Table 4.1 presents using different scales and levels of explanation as the third most prominently utilised pedagogical link by Musa, and as per Table 5.1 and Table 6.1 as the fourth most in Peace's and Katlego's Grade 10 Life Sciences classrooms. Dewi et al. (2023) mentioned that learners still find it difficult to recognise and evaluate explanations of a variety of phenomena, and as a result, perform poorly in answering questions that require scientific literacy. This statement by Dewi et al. (2023) reinforces the point made in Chapter 1 from the Grade 12 NSC (National Senior Certificate) diagnostic reports. The Life Sciences diagnostic reports ranging from 2021 to 2023 all report errors made by Grade 12 learners in interpreting diagrams amongst a lengthy list of errors (DBE, 2021; 2022; 2023). In Batlolona et al.'s (2020) study on physics students' mental models of elasticity, it was found that some learners are able to answer concepts at a macroscopic level, but are unable to do so at a sub-microscopic level. A similar problem in Life Sciences is touched on by Fernandez and Tejada (2018) in their paper on difficulties experienced when learning about the cell. The authors state that learners struggle to conceive the various organisational levels in living beings, which leads them to them not having an appropriate meaning of the concept of focus. This problem corroborates Scott et al.'s (2011) assertion that teachers should be cognisant of and should utilise the symbolic, sub-microscopic, and macroscopic levels of representation.

Now, the prolific use of different levels and scales of explanation by all the teachers follows Scott et al.'s (2011) stipulation on the levels of explanation, and as such deals with the problems presented by Fernandez and Tejada (2018), along with Batlolona et al. (2020). As a result, one can garner that due to their high degree of use of different levels and scales of explanation Peace, Musa and Katlego ensured that their Grade 10 learners are able to recognise and evaluate a variety of explanations (Dewi et al., 2023); and by extension possibly aid their learners in avoiding the common mistakes made in their Grade 12 Life Sciences examination (school-leaving examination) as per the diagnostic reports (DBE, 2021; 2022; 2023).

As can be seen in Table 4.1, Table 5.1 and Table 6.1, pedagogical links made to promote continuity were the least utilised, specifically those proffered by Musa, Katlego and Peace that were intended to develop the scientific story. In Chapter 2, narratives, or rather storylines, were also elaborated on as one of the four vital aspects that should be present in any science classroom. The formation or use of narrative were linked to the PLM form to promote continuity due to the nature of the definition of narratives. Meng et al. (2023) refer to narratives as linking a sequence of episodes within a lesson; while Scott et al. (2011) elucidates the form to promote continuity as the linking of events within a lesson, lesson sequence, and across schooling years. As such, the use of this form pointed at the scientific story or narrative being utilised in those science classrooms.

Musa, Peace and Katlego use links that promote this form of PLM to a minimal extent in each of their lessons and in extension their lesson sequences. This displays a certain lack of instructional alignment, which, as discussed in the literature review chapter, refers to the established competencies that learners are taught in a simple lesson, subject or grade that prepares them for their next level of study that has higher competencies (Kewalramani & Arnott, 2020; Newmann & Nordine, 2020; Tague & Czocher, 2016). A lack of instructional alignment highlights a lack of, or rather a compromise of coherence. Newmann and Nordine (2020) state that coherence between instruction ought to exist within units and across school years. It has already been established that in this study, coherence between units, as pedagogical links made between scientific concepts exists (see Table 4.1, Table 5.1, and Table 6.1). However, coherence across school years is close to none, and as such, the lessons of Musa, Katlego, and Peace were not fully coherent, and by extension did not wholly utilise narratives. In the literature review chapter, it was mentioned that the PLM form to support knowledge building, and the form to promote continuity, are interrelated (Scott et al., 2011); This corroborates the proposition forwarded by Newmann and Nordine (2020). Since the two forms of link-making are interrelated, one can argue that in the classrooms of the Grade 10 Life Sciences who formed part of this study were in most cases partially coherent, presenting incomplete storylines or narratives in their classrooms. The rationale behind this is that the linking of scientific concepts formed part of the scientific storylines and the other portion that formed the part of the storyline, which is the timeline (alluded by the PLM form to promote continuity) least utilised by the Grade 10 Life Sciences teachers.

7.2.2 How the teachers used talk moves to promote links

Buma and Nyamupangedengu's (2020) findings assert that the elicitation of in-depth and diverse answers from learners is achieved through the utilisation of higher order initiating TTMs. Table 4.2, Table 5.2 and Table 6.2 present little to no use of the launch initiating TTMs. This finding is similar to what that presented by Correnti et al. (2015) in their inaugural paper on the ATM framework, which featured a study conducted in mathematics classroom and also reported the low use of launch initiating TTMs in that classroom. From a classroom talk perspective, this finding in this study, the finding of Correnti et al. (2015), along with reasons provided by the teachers, such as the nature of the subject and/or topic, suggest that launch initiating TTMs are not used the least due to the particular teacher, but rather, due to the objective nature of STEM (Science, Technology, Engineering and Mathematics) subjects that rarely provides any opportunity for open-ended questions. This can be seen, for instance, in Musa's lessons of the skeletal and the circulatory system, where opportunities to ask or use open-ended questions are minimal, due to the fact that a bone's name or a blood vessel's name cannot be elicited in open-ended but rather only in close-ended ways. This suggestion however is not the sole idea that this study found, based on this finding.

As can be seen for instance in Excerpt 5.1, the teachers did not just simply utilise initiating moves to initiate discussions as stated by education scholars such as Buma and Nyamupangendengu (2020), Correnti et al. (2015), Khoza and Msimanga (2021) as well as Michaels and O'Connor (2015). In fact, in Excerpt 5.1, Katlego used numerous information providing moves in the middle of the lesson, where the discussion had already been weaved. This can also be seen in all the excerpts presented in this dissertation. This study displayed that initiating moves, particularly those that provide information, were not utilised solely to initiate discussions at the beginning of teaching episodes, but also in the middle of the teaching episode to promote certain pedagogical links regarding sole concepts.

Although least utilised, the launch initiating TTM was predominantly utilised to manage or organise activities in the lesson sequences of the teachers. As elaborated on in the literature review chapter, the managing or organising activities pedagogical link does not have an impact on the promoting of links, but is merely utilised to ensure a smooth flow within a lesson (Scott et al., 2011). This TTM was also utilised in the promoting of other pedagogical links, such as using different scales and levels of explaining; connecting quotidian and scientific explanations; connecting different scientific concepts to each other; connecting various points within a lesson; connecting various points within a lesson sequence; connecting real-life occurrences with scientific explanation; along with referring to different points in different parts of the science curriculum. This TTM, although utilised by the Grade 10 Life Sciences teachers to promote a diverse number of pedagogical links, was utilised once or twice in the promotion of pedagogical links which were not organisational in nature, thus suggesting that they can be utilised for more than just the management of activities within lessons.

The previous three chapters revealed yet another similarity between the lesson sequences of Musa, Katlego and Peace. Another major finding of this study is that rejoinder TTMs were less utilised than initiating TTMs. As elaborated in the interviews of the teachers, this can be attributed to the teachers' awareness of the learners' competencies, learners' responses, as well as time. Little to no use of these moves in this study, contradicts results from many teacher talk move studies, a noticeable one being Khoza and Msimanga's (2021) study, which, similar to this study, was also set in Life Sciences classrooms in South Africa. Th finding suggests that learners were not provided with adequate opportunities for in-depth interactions in the lesson sequences of all three teachers (Khoza, 2023).

In Chapter Two, rejoinders were elaborated on as moves that are utilised to scaffold learners' thinking (Buma and Nyamupangedengu, 2020). Khoza (2023) recognised these moves as the drivers of the unfolding of interactions in science classrooms. Buma and Nyamupangedengu (2020), along with Khoza (2023) state that for linking to occur, rejoinders have to be utilised as well, using the IRE pattern allows for dialogic interactions (Tytler & Aranda, 2015), which are necessary for link-making to occur (Scott et al., 2011). The low use of rejoinders compared to the use of initiators by Musa, Katlego and Peace made their Grade 10 Life Sciences lessons more interactive-authoritative than interactive-dialogic, as classified by Mortimer and Scott (2003) in their paper on communicative approaches. As such, the pattern displayed in this study is different from the one garnered in Scott et al.'s (2011) inaugural paper on PLM. It is vital here to remind the reader that this particular study is inaugural in its nature, due to its focus on the integration of two vital topics in science education research. As such, there is a dearth of studies for comparison, and by extension just the three studies that focus on PLM and communicative approaches may be utilised to evaluate the findings of this study. However, only Scott et al. (2011) presents data that can be utilised for the purposes of comparison and contrast. The variation between the pattern picked up in this study and the pattern found in Scott et al. (2011) can be attributed to numerous factors, such as the difference in science sub-disciplines (Scott et al.'s (2011) study was set in Physical Sciences classroom context) and contexts. Musa, Peace, and Katlego repeatedly mention the nature of the subject as a reason behind the pedagogical decisions they made regarding the use of moves to make links. As such, it can be inferred that the difference in patterns is based on the fact that Life Sciences, although similar to Physical Sciences, remains substantively different.

7.2.3 Factors affecting the use of talk moves and pedagogical link-making

As per chapters 4, 5 and 6, the factors that affected the teachers' use of talk moves to promote pedagogical links are their pedagogical content knowledge (PCK), their experience, their learners' abilities, their learners' interests, the nature of the subject of Life Sciences, the nature of the topic, the learners' prior knowledge, the learners' Life Science competencies, the learners' context, their personal preferences, subject advisors/ facilitators, the availability of resources, the learners' attention spans, their beliefs, learners' learning styles, learners' learning preferences, contextual factors, learners' responses and time. These can be classified into four categories, namely learners, professional requirements, external factors as well as the teacher.

The category learners i.e., their interest, abilities, prior knowledge, Life Sciences competencies, context, attention span, learning styles, learning preferences as well as responses, was expected. In the literature review section, factors such as learners' interests, skill levels, abilities, and motivations (Gemmink et al., 2021; Shavelson et al., 1977) were mentioned as possible factors that may have had an influence on the teachers' use of talk moves to promote pedagogical links. As such, learners as an influence aligned with what prior literature already stated.

The category external factors i.e., time, availability of resources, as well as other contextual factors, were also projected in Chapter 2 and aligned with the lists of factors presented by Gemmink et al. (2021) along with Ambusaidi and Al-Maqbali (2021) that usually influence the pedagogical decisions of teachers.

PCK was expected to be influential, along with teacher's beliefs and preferences. Subject facilitators who were only mentioned by Katlego, however, were not anticipated as such. The teachers i.e., their PCK, their experience, preferences, and beliefs, along with professional requirements i.e., nature of the subject, subject content, as well as subject advisors/facilitators, are further discussed in-depth in what follows.

In the extant literature, it is stated that an increasing teaching experience also increases the effectiveness of teachers (Gore et al., 20204; Hubner et al., 2023; Podolsky et al., 2019) thereby implying that teachers' practice improves when they gain more teaching experience; however, this was not corroborated here. The finding that Peace's utilisation of TTMs and promoting of pedagogical links was considerably more gradually distributed than Katlego's and Musa's along with the finding that Katlego's utilisation of TTMs and promotion of pedagogical links was more gradually distributed by Musa, highlights a particular pattern. It is vital to remind the reader here that Musa has more teaching experience than Katlego, and that Katlego has more teaching experience than Peace. It is possible here to ask after the significance of their teaching experience on their utilisation of TTMs and promotion of pedagogical links. Teaching experience is significant because in the interviews conducted with each of the teachers, teaching experience emerged as an influential factor in numerous answers the teachers provided on their use of TTMs and promoting of pedagogical links. The pattern discussed earlier in this paragraph heavily leans towards teaching experience as an influential factor more than any other factor. Musa with his 36 years of teaching Life Sciences, displays the most uneven distribution in the utilisation of

TTMs and promotion of various pedagogical links; compared to Katlego who has eight years of teaching Life Sciences; while Peace has two years of Life Sciences teaching with the most gradual distribution. This implies that, as far as utilising teacher talk moves to promote pedagogical link-making (PLM) in Life Sciences classrooms is concerned, an increasing teaching experience can be found to deteriorate or rather impair the practice of the teacher. The variance between this study's pattern and the pattern stipulated by literature that an increased teaching experience also increases the effectiveness of the teacher may be attributed to the fact that the studies conducted by Gore et al. (2024), Hubner et al. (20203) and Podolsky et al. (2019) did not focus on the actual teaching, but rather on the secondary results that could be attributed to an increasing teaching experience; whereas this study focused particularly on how teaching experience influenced pedagogical link-making and teacher talk moves. This can be seen in Podolsky et al.'s (2019) study, which sought to link teachers' teaching experience to learner achievement and in Gore et al.'s (2024) study, which sought to garner insight on the way in which years of teaching experience improve the teaching quality.

The nature of the subject, Life Sciences, and the subject content/topics were mentioned as influential by Musa, Katlego and Peace, in their utilisation of TTMs to promote PLM. This can be seen in the findings, presented in chapters Four-Six, on the most utilised TTMs and the most promoted pedagogical links. Life Sciences as a science subject uses concepts to represent all natural phenomena and objects (Koran, 1971), and as such, it can be seen as a knowledge-based subject. Peace, Katlego, and Musa all utilised the provides information TTM to promote pedagogical links that support knowledge building (the most promoted PLM form by all the teachers). This similarity shared by all the teachers can be attributed to the nature of the subject and the content as influential factors. Here, one can argue that these factors played a role in this TTM and PLM form being the most prevalent in all three teachers' lessons and across nine different topics (see Table 4.2, 5.2 and 6.2) because they are mainly utilised or promoted to impart information or knowledge, which leads back to the knowledge-based nature of Life Sciences.

7.3 Addressing the main research question

The main research question that guided this study was, 'how do Grade 10 Life Sciences teachers use talk moves to promote pedagogical links in their classrooms?' This main question was to be addressed by the following sub-questions, what pedagogical links are made by Grade 10 Life Sciences teachers in their classrooms, in what ways do the Grade 10 Life Sciences use teacher talk moves to promote pedagogical links, as well as what influences the Grade 10 Life Sciences teachers' use of teacher talk moves to promote pedagogical link-making? In this section, I describe how the findings regarding the sub-questions address the main question.

All the Grade 10 Life Sciences teachers made nine of the ten links. Katlego and Peace made the same pedagogical links, which excluded the use of analogies, whereas Musa's pedagogical links excluded connecting consecutive activities within a lesson. All the teachers utilised the using different forms of representation link the most and all three teachers under-utilised the pedagogical link, which are used to promote continuity. The connecting every day and scientific explanations pedagogical link is the second highest utilised pedagogical link by Katlego and Peace, while Musa's second highest utilised pedagogical link is using different scales and levels of explanation. Katlego made the least number of pedagogical links, while Peace made the most pedagogical links. All the teachers made more than a hundred pedagogical links in their three lessons, none of which exceeded two hours; therefore, one can conclude that an extensive number of pedagogical links were made in the Grade 10 Life Sciences classrooms.

The most prevalent teacher talk move utilised to promote the pedagogical links in the classrooms of all the three Grade 10 Life Sciences teachers is the provides information teacher talk moves, which is followed by the literal initiating teacher talk move. The launch initiating teacher talk moves was the least utilised teacher talk moves in the promoting of links in of the lesson sequences of the Grade 10 Life Sciences teachers. Since the provides information and the literal initiating teacher talk move are utilised in the promoting of most of the pedagogical links by the Grade 10 Life Sciences teachers and rejoinder moves are rarely utilised. One can conclude that, since knowledge building pedagogical links are the most prevalent, and that initiating teacher talk moves are the most prevalent in the making of these links, initiating moves are utilised in the making of knowledge building pedagogical links.

The following factors influenced the Grade 10 Life Sciences teachers' utilisation of teacher talk moves to promote pedagogical links i.e., the learners, the teachers themselves, professional requirements as well as external factors.

The central question of the study is that information providing moves along with literal initiating moves were majorly utilised to promote various pedagogical links, the most predominant being the use of different representation forms. This predominant promotion of different forms of representation through the use of literal initiators and information providing moves was mainly influenced by external factors and professional requirements.

7.4 Significance of the study

Earlier on this dissertation, it was observed that, although the Life Sciences CAPS document stipulates that teachers should make links, it does not outline how. This research study provides insight into how teacher can use teacher talk moves to promote pedagogical links and also highlights possible factors that would influence these Life Sciences teachers to use certain moves and to promote certain links. The findings also highlight a possible reason, low promotion of continuity links, to the common errors and mistakes that Grade 12 learners make in their National Senior Certificate examination.

The overarching topic of this study, viz. pedagogical link-making, has only been published in twelve publications, where, as such, not much is known about this topic as both a process and as a framework. This study adds to the existing pool of knowledge on pedagogical link-making as both a process and a framework, by demonstrating how teacher talk moves can be utilised to promote links. The link-making literature of studies contextually based in both African and South African classrooms is also increased in number by this study, as only one study existed prior to this. This study does not merely add to the literature on link-making, but it also adds on to the pool of knowledge of talk moves as tools that can be used to promote the scientific story (by introducing a PLM-TTMs conceptual framework), thereby adding to the vast research on teacher talk moves in science classrooms.

7.5 Reflections

In this section, I discuss the new skills and knowledge that I have acquired during the course of this particular study. I also reflect on challenges that I encountered and how I overcame them. Furthermore, I discuss how the process of research contributed to my development in both the professional and personal avenues by focusing on the methodological and theoretical aspects.

7.5.1 Methodological reflections

Grounding this study in the interpretivist paradigm and utilising a qualitative research strategy worked particularly well for this study, where the characteristic of both this paradigm and research strategy allowed for multiple realities to be true, allowing me to explore the phenomenon of Grade 10 Life Science teachers using talk moves to make pedagogical links in their classrooms without any preconceived notions as to what factors played a role as such factors such as teaching experience, the nature of the subject and time were found through the analysis of data, instead of the common factors such as lack of resources that one would expect to make a significant impact in the teaching practices of teachers who are based in Gauteng township schools.

Another challenge faced in utilising this multiple case study design involved the design of the unique interview schedules, where staying true to the exploration of what occurred in the individual Grade 10 Life Sciences teachers' classrooms and balancing an element of consistency in the interview schedule questions in each of the schedules proved rather challenging. To ensure the above-mentioned aspect of the interview schedules were addressed, I resorted to the third secondary research question as a guide, where in this manner, only the video data deemed relevant to this research question were further explored by the interview schedule questions and in turn, an element of consistency was maintained, despite the unique natures of the interview schedules. In the process of designing the interview schedules, I acquired a skill I believe will be particularly useful in future research endeavours featuring interviews as a data collection method, in my academic career.

Although utilising semi-structured interviews yielded valuable results in this study, it is not without drawbacks. It did not provide me with the opportunity to play back certain events from the lessons of the teachers during the interviews (a feature of video-stimulated recall interviews), and as such, when I asked the teachers about certain events within their lesson some were at a loss. Had I utilised video-stimulated recall interviews, most of the events for which the teachers were required to explain their rationale would have been better communicated, and as such, richer responses would likely have been possible.

Utilising both analysis methods aided in the thorough understanding of the data collected from the interviews i.e., by utilising both narrative analysis and analysis of narratives, I was allowed to present the factors as themes while also narrating how these factors were factors and how these factors were relevant to the lesson observed prior. This greatly contributed to the exceptional flow of presenting findings and also to understanding how certain factors actually influenced the use of talk moves and the promotion of pedagogical links.

7.5.2 Data analysis reflection

Analysing the Video data was a success, which can be attributed to having had an analytical framework with priori codes, which made this process relatively seamless, where the analytical framework ensured that only identified pedagogical links were further analysed for TTMs to best explore how the TTMs were utilised in order to promote pedagogical links by the Grade 10 Life Sciences teachers.

Since the analytical framework that had a priori codes was used to analyse the Video data, some aspects of teacher talk may have been missed. Since talk moves can be analysed by the use of multiple frameworks, some of which do not feature the same type of moves e.g., where the framework of Chapin et al. (2009) features wait time, while the ATM framework of Correnti et al. (2015) does not, it is possible that the priori codes that I utilised did not account for other types of talk moves.

Using both deductive and inductive analysis methods ensured that I did not miss any valuable data. The knowledge of factors that could have an influence of this kept the interview analysis organised, whereas allowing for the narratives to guide me in terms of the factors that are actually there (although not in my preconceived list) ensured that I did not lose any data. Had I solely analysed these interviews deductively, only the factors that were on my preconceived list would have been found and reported on, and a wide-range of factors such as time would have been missed.

7.5.3 Conceptual framework reflection

The PLM-TTMs conceptual framework proved rather useful in guiding the research study. Firstly, it underpinned the analytical framework, which was utilised in the analysis of the Video data of the individual teachers. Secondly, it also guided this study in terms of the order in which various data collection methods were utilised i.e., the conceptual framework initially acknowledges both PLM and TTMs as tools which are utilised on a social plane in the classroom, and then acknowledges that they (PLM and TTMs) can in fact be utilised simultaneously, and finally highlights that the utilisation of PLM and TTMs as being dependent on numerous factors. This provided a clear picture that lessons had to be observed first, and only thereafter should the analysis of those lessons interviews be conducted.

As a framework emergent from the adaptations of two major frameworks i.e., that of Scott et al. (2011) PLM framework and Correnti et al. (2015), it was expected that certain aspects of this particular study's framework would raise questions particularly those arising from the use of a new framework adapted from already existing frameworks. The aspect of focus here involves the incorporation of the launch initiating TTM in the framework, this study along with that of Correnti et al. (2015), which debuted the ATM framework, reported a relatively low utilisation of the launch initiating TTM. This finding raises the question as to whether this TTM ought to be excluded from the framework, and only be acknowledged as existing, similarly to how the third form of PLM (PLM to encourage emotional engagement) was demarcated out of this framework, for education research set in STEM classrooms.

7.5.4 Personal reflections

Selecting Grade 10 Life Sciences as a grade in which the study was conducted proved efficacious. In the first chapters of this dissertation, I mentioned that Grade 10 serves as the perfect, because is a grade in which learners actually start Life Sciences after years of having Natural Sciences (a basic science subject) for six years. This grade was supposed to be ideal, because this is the grade in which teachers were given ample opportunities to promote pedagogical links, meaning that it was ideal to use to explore link-making. The specific use of this grade led to discoveries such as the little-to-no use of links made within the greater basic education science curriculum, where, as such, this choice of Grade 10 as the ideal grade for this study worked well.

In the planning stages of this study (proposal stage), the goal was to view five lessons per teacher. This, however, did not work in the actual carrying out of the study, as observing and transcribing five lessons each ranging from 30 to 60 minutes (some were in double periods), posed a challenge due to time constraints. Time constraints were not the sole challenge, numerous activities that occurred at the schools in which participants were located, where their lessons were either interrupted numerous times, or were moved up; while in some teachers' cases, they had already finished the outlined annual teaching plan for Life Sciences. As such, I had to compromise to three lessons so as to deal with time constraints and the contextual issues arising from the activities conducted in my participants' schools.

7.6 Recommendations

7.6.1 Recommendations for pre-service teacher training programmes

This study reported a low use of analogies in Musa's case, and the non-use of analogies in for Katlego and Peace. As such, this study recommends that pre-service teacher training programs incorporate the use of analogies into the syllabi of science education modules. Pre-service teachers would benefit from possessing knowledge on using analogies due to analogies' potential to enhance coherence.

The PLM form to promote continuity was the least promoted in the teachers' classrooms. This was discussed above, indicating incomplete storylines/narratives and by extension affected the coherence in those teacher's classrooms. As such, this study also recommends that pre-service teacher training programmes incorporate a scientific storyline into the syllabi of science education modules.

Another major finding of this study was that the literal initiator and the information providing moves were heavily utilised by all the teachers to promote various pedagogical links. This study also found that the teachers did not use talk moves in a more evenly spread manner. This study recommends that talk moves as a pedagogical tool be incorporated into the syllabi of science education modules in pre-service teacher training programmes.

7.6.2 Recommendations for in-service teacher training programmes

One of the major findings of this study was lower utilisation of PLM to support continuity pedagogical links by all three Grade 10 Life Sciences teachers. In the content training that is offered to in-service Grade 10 Life Sciences teachers, content delivery tools such as pedagogical link-making and teacher talk moves ought to be prioritised alongside the discussions of scope. This would aid in making the Life Sciences teachers aware of the importance of continuity links.

7.6.3 Recommendations for future studies

The knowledge-based nature of Life Sciences was discovered as a possible factor that influenced the Grade 10 Life Sciences teachers to utilising provides information TTMs, and promoting knowledge building pedagogical links in a greater quantity than any other PLM form or TTM. Further research into this finding ought to be conducted such that the nature of Life Sciences be further explored for its ability to significantly influence either the pedagogical links that Life Sciences teachers utilise and promote in their classrooms, the TTMs, or both.

The findings reveal a noticeable deficiency in the utilisation of the launch initiating TTMs in promoting pedagogical links, corroborating the debut study by Correnti et al. (2015) on the ATM framework, which also reported the same results in terms of launch initiating TTMs use. In the discussion section, it was implied that this may be a general pattern in classroom context, where, as such, it is suggested and is imperative that this implication be further explored in various STEM classroom contexts in order to determine whether this implication is an accepted notion in STEM education or not.

Although utilised less than other initiating moves, the launch initiating TTM was effectively utilised to promote managing and/or organising pedagogical links as discussed in the discussion section. It was also stated that this TTM was utilised, although merely once or twice, in the promoting of other pedagogical links. Future research in any subject field in education, utilising the PLM-TTMs framework launched by this particular study ought to consider the utility of this TTM in the promotion of other pedagogical links.

Time was reported as one of the possible factors that influenced the low utilisation of rejoinder TTMs by the Grade 10 Life Sciences teachers. This study suggests that future research be conducted in Grade 10 Life Sciences classrooms with topics similar to the ones taught by the Grade 10 Life Sciences teachers who participated in this with the aim of determining whether time proves to be a definitively a factor or not. Future research would benefit from an action research design and should feature a TTMs specialist as the teacher delivering the content as a means to clearly determine whether or not given the same lesson timeframe and content, those lessons would yield the same results in terms of rejoinder use. A further exploration of this finding could potentially provide much required insight on the effect of time on the quality of teaching and learning.

This study reported a decline in the Grade 10 Life Sciences teachers' practice, as far as PLM and TTMs are concerned, with an increasing teaching experience. As such, it suggests that future research ought to explore this finding, particularly since increasing teaching experience as instrumental to teaching practice is dependent on learner performance and not on reviewing the actual classroom practice of the teachers.

I reflected on how the priori codes used in this study, particularly those used to analyse talk moves, could have led to this study missing particular aspects of teacher talk in the various Life Sciences teachers' classrooms. As such, this study recommends that future research examine the multiple teacher talk frameworks and how they could be combined in order to gather a complete notion of teacher talk. This could provide an integrated talk move framework for future teacher talk move studies.

7.7 Concluding remarks

There is a connection between the teacher talk moves utilised and the PLM forms promoted in the Life Sciences classrooms. Various teacher talk moves were utilised to promote various pedagogical links those of note being initiating moves to promote links that support the building of knowledge. This utilisation of moves to promote links was influenced by a wide range of factors, thereby asserting that the use of talk moves to promote talk moves, whether consciously or unconsciously done, is driven by a pedagogical decision, influenced by certain factor(s). This study adds on to literature on pedagogical links, talk moves, teaching experience, and pedagogical decision-making. The methodology utilised in this study aided in the production of these findings and the analysis methods utilised were ideal. The findings of this study, led to numerous new and exciting questions about the known and unknown in the science education research, and these impact the education research landscape more broadly. These findings also can be utilised to improve both pre- and in-service teacher training programmes, which constitute the first step in education reform.

References

Abdulhamid, L., & Venkat, H. (2018). Primary mathematics teachers' responses to learners' offers: An 'elaboration' framework. *The Journal of Mathematical Behavior, 51*, 80-94.

Adhabi, E., & Anozie, C. B. (2017). Literature review for the type of interview in qualitative research. *International Journal of Education, 9*(3), 86-97.

Aguiar, O. G., Mortimer, E. F., & Scott, P. (2010). Learning from and responding to students' questions: The authoritative and dialogic tension. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *47*(2), 174-193.

Ambusaidi, A. K., & Al-Maqbali, F. Y. (2022). Exploring pedagogical decision making from the lens of science teachers in response to different pedagogical issues. *Social Sciences & Humanities Open, 5*(1), 100236.

Andrade, C. (2021). The inconvenient truth about convenience and purposive samples. *Indian Journal of Psychological Medicine, 43*(1), 86-88.

Antwi, S. K., & Hamza, K. (2015). Qualitative and quantitative research paradigms in business research: A philosophical reflection. *European Journal of Business and Management*, *7*(3), 217-225.

Aranda, M. L., Lie, R., Selcen Guzey, S., Makarsu, M., Johnston, A., & Moore, T. J. (2020). Examining teacher talk in an engineering design-based science curricular unit. *Research in Science Education, 50,* 469-487.

Ary, D., Jacobs, L. C., & Razavieh, A. (2018). *Introduction to Research in Education* (10th ed.). Wadsworth Thomson Learning.

Athanases, S. Z., & Oliveira, L. C. D. (2010). Toward program-wide coherence in preparing teachers to teach and advocate for English language learners. In *Teacher preparation for linguistically diverse classrooms* (pp. 215-235). Routledge.

Atuhurra, J., & Kaffenberger, M. (2022). Measuring education system coherence: Alignment of curriculum standards, examinations, and teacher instruction in Tanzania and Uganda. *International Journal of Educational Development*, *92*, 102598.

Aung, K. T., Razak, R. A., & Nazry, N. N. M. (2021). Establishing validity and reliability of semi-structured interview questionnaire in developing risk communication module: A pilot study. *Edunesia: Jurnal Ilmiah Pendidikan, 2*(3), 600-606.

Ausubel, D. P. (1963). *The psychology of meaningful verbal learning.* Grune & Stratton.

Ausubel, D., Novak, J., & Hanesian, H. (1968). *Educational Psychology* (6th ed.) Holt. Rineharty Winston.

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, E. R., Gray, R., & Grinath, A. S. (2023). Teacher talk moves as pedagogical tools for eliciting and working with learner ideas in an undergraduate general biology laboratory. *Science Education, 107*(1), 89-123.

Barton, R., & Elliott, J. (2024). Designing a competency based framework for assessing student teachers: The UEA Approach. In *Developing Competent Teachers* (pp. 9-27). Routledge.

Bay, E. (2016). Developing a Scale on" Factors Regarding Curriculum Alignment". *Journal of Education and Training Studies*, *4*(5), 8-17.

Becher, A. (2022). When context meets knowledge in university professional education: organizational factors influencing coherence in teaching and social work. *Higher Education*, *83*(3), 577-595.

Beier, E. J., Chantavarin, S., Rehrig, G., Ferreira, F., & Miller, L. M. (2021). Cortical tracking of speech: toward collaboration between the fields of signal and sentence processing. *Journal of Cognitive Neuroscience*, *33*(4), 574-593.

Bernátová, R., Bernát, M., Poráčová, J., Nagy, M., Sedlák, V., Sepešiová, M., & Vadašová, B. (2020). Visualization of the logical structure of biologically and ecologically oriented curriculum and its application in teaching to increase the level of understanding of causality (Coherence of cause and effectin) in the curriculum. *Journal of Science Education*, 54-75.

Bonner, S. M., Torres Rivera, C., & Chen, P. P. (2018). Standards and assessment: coherence from the teacher's perspective. *Educational Assessment, Evaluation and Accountability*, *30*, 71-92.

Billingsley, B., & Ramos Arias, A. (2017). Epistemic insight and classrooms with permeable walls. *School Science Review*, *99*(367), 44-53.

Brigandt, I. (2020). How are biology concepts used and transformed. *Philosophy of Science for Biologists*, *8*, 79-101.

Britannica dictionary. (online). *Instruction.* In *Britannica.com*. Retrieved October 5, 2023, from https://www.britannica.com/dictionary/instruction

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.

Cambridge Dictionary. (online). Life Sciences. In *dictionary.cambridge.org*. Retrieved October 5, 2023, from https://dictionary.cambridge.org/dictionary/english/life-science?q=life+sciences

Cambridge Dictionary. (online). Coherence. In *dictionary.cambridge.org*. Retrieved December 1, 2023, from https://dictionary.cambridge.org/dictionary/english/coherence

Campbell, S., Greenwood, M., Prior, S., Shearer, T., Walkem, K., Young, S., & Walker, K. (2020). Purposive sampling: complex or simple? Research case examples. *Journal of Research in Nursing, 25*(8), 652-661.

Carrillo, N. M. R., Valle, V. V. Y., & Labre, M. G. P. (2019). Storytelling strategy to improve coherence in writing skills development. *Explorador Digital*, *3*(3.1), 123-142.

Chapin, S. H., O'Connor, M. C., & Anderson, N. C. (2009). *Classroom discussions: Using math talk to help learners learn, Grades K-6*. Math Solutions.

Chen, H. C., O'Sullivan, P., Teherani, A., Fogh, S., Kobashi, B., & Ten Cate, O. (2015). Sequencing learning experiences to engage different level learners in the workplace: An interview study with excellent clinical teachers. *Medical Teacher*, *37*(12), 1090-1097.

Cherbow, K., McKinley, M. T., McNeill, K. L., & Lowenhaupt, R. (2020). An analysis of science instruction for the science practices: Examining coherence across system levels and components in current systems of science education in K-8 schools. *Science Education*, *104*(3), 446-478.

Chittum, J. R., Jones, B. D., Akalin, S., & Schram, Á. B. (2017). The effects of an afterschool STEM program on students' motivation and engagement. *International Journal of STEM Education*, *4*, 1-16.

Clarke, S. N., Howley, I., Resnick, L., & Rosé, C. P. (2016). Student agency to participate in dialogic science discussions. *Learning, Culture and Social Interaction, 10*, 27-39.

Cobb, P., Jackson, K., Henrick, E., & Smith, T. M. (2020). *Systems for instructional improvement: Creating coherence from the classroom to the district office*. Harvard Education Press.

Cohen, L., Manion, L., & Morrison, K. (2017). *Research methods in education* (8th ed.) RoutledgeFalmer.

Coldwell, M., Greany, T., Higgins, S., Brown, C., Maxwell, B., Stiell, B., ... & Burns, H. (2017). *Evidence-informed teaching: an evaluation of progress in England. Research Report*. Department for Education.

Collins Dictionary. (online). Coherence. In *Collins.dictionary.com*. Retrieved December 1, 2023, from https://www.collinsdictionary.com/dictionary/english/coherence

Collins Dictionary. (online). Instruction. In *Collins.dictionary.com*. Retrieved October 5, 2023, from https://www.collinsdictionary.com/dictionary/english/instruction

Collins Dictionary. (online). Life Sciences. In *Collins.dictionary.com*. Retrieved October 5, 2023, from https://www.collinsdictionary.com/dictionary/english/life-sciences

Contini, A., Giuliani, A., & Manera, L. (2020). Stories about nature as aesthetic experience in science education. In Electronic Proceedings of the ESERA 2019 Conference. *The Beauty and Pleasure of Understanding: Engaging With Contemporary Challenges Through Science Education* (pp. 175-183).

Cooper, G. (2023). Examining science education in ChatGPT: An exploratory study of generative artificial intelligence. *Journal of Science Education and Technology*, *32*(3), 444-452.

Corbin, J., & Strauss, A. (2015). *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory* (4th ed.). Sage.

Correnti, R., Stein, M. K., Smith, M. S., Scherrer, J., McKeown, M., Greeno, J., & Ashley, K. (2015). *Socializing intelligence through Academic Talk and Dialogue.* Casemate Group.

Darvishi, S. (2020). The use of Slack as a social media in higher education: Students perceptions of advantages and disadvantage of Slack during learning process.

Da Silva, J. B. (2020). David Ausubel's theory of meaningful learning: an analysis of the necessary conditions. *Research, Society and Development, 9*(4), e09932803. https://doi.org/10.33448/rsd-v9i4.2803

DBE (2021). *NSC Examinations 2021: Diagnostic report-Part 1.* https://www.education.gov.za/Portals/0/Documents/Reports/2021NSCReports/2021%20Diagnostic%20Report%20Part%201%20Content%20Subjects.pdf?ver=2022-02-08-103527-000

DBE (2022). *NSC Examinations 2022: Diagnostic report-Part 1.* https://www.education.gov.za/Portals/0/Documents/Reports/Diagnostic%20Reports%202022/Diagnostic%20Report%20PART%201%20Non-languages.pdf?ver=2023-02-14-125540-000

DBE (2023). *NSC Examinations 2023: Diagnostic report Book 1.* https://www.education.gov.za/Portals/0/Documents/Reports/Diagnostic%20Reports%

202022/Diagnostic%20Report%202023%20Book%201.......pdf?ver=2024-02-27-144522-073

De Carvalho, R. (2016). Science initial teacher education and superdiversity: Educating science teachers for a multi-religious and globalised science classroom. *Cultural Studies of Science Education, 11*, 253-272.

De Quadros, A. L., de Almeida, L. T. G., & Dias, M. G. (2018a). Organic chemistry lectures in Higher Education and pedagogical link-making. *Journal of Education and Social Policy, 5*(1), 120-129.

De Quadros, A. L. D., Silva, A. S. F., & Mortimer, E. F. (2018b). Pedagogical link-making in higher education science classrooms. *Química Nova, 41*(2), 227-235.

Department of Basic Education (DBE). (2011). *Curriculum and Assessment Policy Statement Life Sciences Grades 10-12.* https://www.education.gov.za/Portals/0/CD/National%20Curriculum%20Statements%20and%20Vocational/CAPS%20FET%20_%20LIFE%20SCIENCES%20_%20GR%2010-12%20Web_2636.pdf?ver=2015-01-27-154429-123

Díaz-García, A., Franke, M., Herrero, R., Ebert, D. D., & Botella, C. (2021). Theoretical adequacy, methodological quality and efficacy of online interventions targeting resilience: a systematic review and meta-analysis. *European Journal of Public Health, 31*(Supplement_1), i11-i18.

Durán, L. (2018). Understanding young children's everyday biliteracy: "Spontaneous" and "scientific" influences on learning. *Journal of Early Childhood Literacy, 18*(1), 71-96.

Durdona, K. (2019). Advantages and disadvantages of observation. *Вопросы науки и образования, 7* (53), 144-146.

Duschl, R. A. (2019). Learning progressions: Framing and designing coherent sequences for STEM education. *Disciplinary and Interdisciplinary Science Education Research*, *1*(1), 1-10.

Ekanoye, O. (2020). *Modelling a Framework for Mobile Virtual Network Operators in Nigeria: An Interpretivism Perspective* (Doctoral dissertation, The Information and Communication Technology University, Cameroon).

Engeström, Y. (2020). Ascending from the abstract to the concrete as a principle of expansive learning. *Psihologičeskaâ nauka i obrazovanie= Психологическая наука и образование*, *25*(5), 31-43.

Erfanrad, S., Fazilatfar, A. M., & Maftoon, P. (2020). Systemic-theoretical instruction vs. discovery learning: The case of Iranian EFL learners' acquisition of grammar. *Journal of Modern Research in English Language Studies*, *7*(1), 45-78.

Etikan, I., & Bala, K. (2017). Sampling and sampling methods. *Biometrics and Biostatistics International Journal, 5*(6), 215- 217.

Fogarty, R. (1991). The mindful school: How to integrate the Curricula. *Skylight Pub*.

Frigg, R., & Nguyen, J. (2020). *Modelling nature: An opinionated introduction to scientific representation*. Cham: Springer.

Galal, S. (2022). Number of Schools in South Africa in 2021, by sector. Statista. https://www.statista.com/statistics/1262871/number-of-schools-in-south-africa-by-sector/

Ganesh, A., Palmer, M., & Kann, K. (2021). *What would a teacher do? Predicting future talk moves*. arXiv preprint arXiv:2106.05249.

García, P. N. (2018). Concept-based instruction: Investigating the role of conscious conceptual manipulation in L2 development. In *The Routledge handbook of sociocultural theory and second language development* (pp. 181-196). Routledge.

Gazdag, E., Nagy, K., & Szivák, J. (2019). "I Spy with My Little Eyes..." The use of video stimulated recall methodology in teacher training–The exploration of aims, goals and methodological characteristics of VSR methodology through systematic literature review. *International Journal of Educational Research, 95,* 60-75.

Gemmink, M. M., Fokkens-Bruinsma, M., Pauw, I., & Van Veen, K. (2021). How contextual factors influence teachers' pedagogical practices. *Educational Research, 63*(4), 396-415.

Gilewski, A., Litvak, M., & Ye, L. (2022). Promoting metacognition through measures of linked concepts with learning objectives in introductory chemistry. *Chemistry Education Research and Practice*, *23*(4), 876-884.

Gore, J., Rosser, B., Jaremus, F., Miller, A., & Harris, J. (2024). Fresh evidence on the relationship between years of experience and teaching quality. *The Australian Educational Researcher*, *51*(2), 547-570.

Grapin, S., Haas, A., Goggins, M., Llosa, L., & Lee, O. (2019). Beyond general-purpose teacher talk moves. *Science and Children, 57*(4), 36-43.

Grinath, A. S., & Southerland, S. A. (2019). Applying the ambitious science teaching framework in undergraduate biology: Responsive talk moves that support explanatory rigor. *Science Education, 103*(1), 92-122.

Groenland E. & Dana L. P. (2019). *Qualitative methodologies and data collection methods : Toward increased rigour in management research.* World Scientific. https://search.ebscohost.com/login.aspx?direct=true&scope=site&db=nlebk&db=nlabk&AN=2327336.

Gustafsson, J. (2017). *Single case studies vs. multiple case studies: A comparative study*. Academy of Business, Engineering and Science, Halmstad University, Halmstad, Sweden.

Fortus, D., Sutherland Adams, L. M., Krajcik, J., & Reiser, B. (2015). Assessing the role of curriculum coherence in student learning about energy. *Journal of Research in Science Teaching*, *52*(10), 1408-1425.

Halkias, D., & Neubert, M. (2020). Extension of theory in leadership and management studies using the multiple case study design. *Available at SSRN 3586256*.

Hansen, J., & Richland, L. E. (2020). Teaching and learning science through multiple representations: Intuitions and executive functions. *CBE—Life Sciences Education*, *19*(4), ar61.

Harding, J. (2018). *Qualitative data analysis: From start to finish*. Sage.

Hedegaard, M. (2020). Ascending from the Abstract to the Concrete in School Teaching-the double Move between Theoretical Concepts and Children's Concepts. *Psychological Science & Education*, *25*(5).

Heredia, S. C. (2020). Exploring the role of coherence in science teachers' sensemaking of science-specific formative assessment in professional development. *Science Education*, *104*(3), 581-604.

Howe, C., Hennessy, 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.

Hu, L., & Chen, G. (2023). A systematic review and meta-analysis of productive peer talk moves. *Journal of Behavioral Education*, 1-33.

Hußner, I., Lazarides, R., Symes, W., Richter, E., & Westphal, A. (2023). Reflect on your teaching experience: systematic reflection of teaching behaviour and changes in student teachers' self-efficacy for reflection. *Zeitschrift für Erziehungswissenschaft*, *26*(5), 1301-1320.

Hudicourt-Barnes, J. (2003). The use of argumentation in Haitian Creole science classrooms. Harvard Educational Review, 73(1), 73-93.

Jabeen, S. S. (2014). Implementation of Communicative Approach. English Language Teaching, 7(8), 68-74.

Jacob, F. I. L. G. O. N. A., John, S. A. K. I. Y. O., & Gwany, D. M. (2020). Teachers' pedagogical content knowledge and students' academic achievement: A theoretical overview. *Journal of Global Research in Education and Social Science*, *14*(2), 14-44.

Jaja, I. R., Idoniboye, O., & Amadi, C. C. (2022). A Critique of the Positivist Paradigm in Human Sciences. International Journal of Research and Innovation in Social Science, 6(3), 224-229.

Jiang, Y. (2018). The effective application of fragmented learning guided by constructivism. *International Journal of Education, Culture and Society*, *3*(1), 10-13.

Jin, H., Mikeska, J. N., Hokayem, H., & Mavronikolas, E. (2019). Toward coherence in curriculum, instruction, and assessment: A review of learning progression literature. *Science Education*, *103*(5), 1206-1234.

Jördens, J., Asshoff, R., Kullmann, H., & Hammann, M. (2016). Providing vertical coherence in explanations and promoting reasoning across levels of biological organization when teaching evolution. *International Journal of Science Education*, *38*(6), 960-992.

Kalogiannakis, M., Papadakis, S., & Zourmpakis, A. I. (2021). Gamification in science education. A systematic review of the literature. *Education sciences*, *11*(1), 22.

Keeley, P. (2016). Teacher talk moves. Science and Children, 53(8), 24-26.

Kewalramani, S., Arnott, L., & Dardanou, M. (2020). Technology-integrated pedagogical practices: a look into evidence-based teaching and coherent learning for young children. *European Early Childhood Education Research Journal*, *28*(2), 163-166.

Khong, T. D. H., Saito, E., & Gillies, R. M. (2019). Key issues in productive classroom talk and interventions. Educational Review, 71(3), 334-349.

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., & Makgata, T. I. (2024). Interaction of initiating prompts and the patterns of student engagement in higher education biology classrooms. Journal of Pedagogical Sociology and Psychology, 6(2), 64-77.

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, 52,* 1717-1734.

Kim, M. Y., & Wilkinson, I. A. (2019). What is dialogic teaching? Constructing, deconstructing, and reconstructing a pedagogy of classroom talk. *Learning, Culture and Social Interaction, 21*, 70-86.

Kivunja, C., & Kuyini, A. B. (2017). Understanding and applying research paradigms in educational contexts. *International Journal of Higher Education, 6*(5), 26-41.

Koran Jr, J. J. (1971). Concepts and concept-formation in the teaching of biology. *The American Biology Teacher*, 405-408.

Korstjens, I., & Moser, A. (2018). Series: Practical guidance to qualitative research. Part 4: Trustworthiness and publishing. *European Journal of General Practice, 24*(1), 120-124.

Kristiansen, S. (2022). Qualitative online data collection: Towards a framework of ethical decision-making. *Qualitative Report, 27*(12), 2686-2700.

Landrum, B. (2019). 'See me as i see myself': A phenomenological analysis of grade bump requests. *Qualitative Research in Education*, *8*(3), 315-340.

Lantolf, J. P., Xi, J., & Minakova, V. (2021). Sociocultural theory and concept-based language instruction. *Language Teaching*, *54*(3), 327-342.

Lazzerini, S. (2020). *Investigating talk moves in key stage 3 mathematics classrooms* (Doctoral dissertation, University of Oxford).

Lee, C., Lee, T., Dickerson, D., Castles, R., & Vos, P. (2021). Comparison of peer-to-peer and virtual simulation rehearsals in eliciting learner thinking through number talks. *Contemporary Issues in Technology and Teacher Education, 21*(2), 294-324.

Lehesvuori, S., & Ametller, J. (2021). Exploring coherence and authorship in pedagogical link-making in science. *International Journal of Science Education, 43*(17), 2791-2813.

Lehesvuori, S., Lehtinen, A., Hämäläinen, R., Maunuksela, J., & Koskinen, P. (2023). Student-centredness in physics laboratory teaching sessions. *Learning, Culture and Social Interaction*, *43*, 100773.

Lehtinen, A., Lehesvuori, S., & Viiri, J. (2019). The connection between forms of guidance for inquiry-based learning and the communicative approaches applied—a case study in the context of pre-service teachers. *Research in Science Education, 49*(6), 1547-1567.

Lemke, J.L. (1990). *Talking science: Language, learning and values*. Ablex Publishing Corporation.

Liang, K., Zhai, J., Ren, Y., Zhang, Y., & Wang, Y. (2023). Fragmented Knowledge Clustering method based on SOM. *International Journal of System Assurance Engineering and Management*, *14*(1), 188-195.

Kansanen, P. (2009). Subject-matter didactics as a central knowledge base for teachers, or should it be called pedagogical content knowledge? *Pedagogy, Culture & Society*, *17*(1), 29-39.

Kim, M. Y., & Wilkinson, I. A. (2019). What is dialogic teaching? Constructing, deconstructing, and reconstructing a pedagogy of classroom talk. *Learning, Culture and Social Interaction*, *21*, 70-86.

Khong, T. D. H., Saito, E., & Gillies, R. M. (2019). Key issues in productive classroom talk and interventions. *Educational Review*, *71*(3), 334-349.

Kokkonen, T., & Schalk, L. (2021). One instructional sequence fits all? A conceptual analysis of the applicability of concreteness fading in mathematics, physics, chemistry, and biology education. *Educational Psychology Review*, *33*(3), 797-821.

Kromka, S. M., & Goodboy, A. K. (2019). Classroom storytelling: Using instructor narratives to increase student recall, affect, and attention. *Communication Education*, *68*(1), 20-43.

Mainali, B. (2021). Representation in teaching and learning mathematics. *International Journal of Education in Mathematics, Science and Technology*, *9*(1), 1-21.

Mannik, L., & McGarry, K. (Eds.). (2017). *Practicing ethnography: A learner guide to method and methodology.* University of Toronto Press.

Maree, K. (2016). *First steps in research* (3rd ed.). Van Schaik.

Marques, R., & Xavier, C. R. (2019). Inferences on the construction of the critical sense from environmental education in science education. *International Journal of Development Research*, *9*(10), 30280-30290.

Martins, R. F., Moro, L., & Mortimer, E. F. (2018). The use of Pedagogical link-making in General Pathology classes: Materialization of the link with the curriculum and with the profession. *Ciência and Educação (Bauru), 24,* 1013-1027.

Mason, P., Augustyn, M. M., & Seakhoa-King, A. (2021). Mixed methods research in tourism: a systematic sequential approach. *Folia Turistica*, *56*, 1-26.

McGrath, C., Palmgren, P. J., & Liljedahl, M. (2019). Twelve tips for conducting qualitative research interviews. Medical teacher, 41(9), 1002-1006.

McPhail, G. (2021). The search for deep learning: A curriculum coherence model. *Journal of Curriculum Studies*, *53*(4), 420-434.

Meng, R., Yeo, A., Ding, M., & Alibali, M. W. (2023). Linking representations of equality in first-grade mathematics lessons in China. *Educational Research for Policy and Practice*, 1-23.

Merriam-Webster. (online). Coherence. In Merriam-Webster.com dictionary. Retrieved October 5, 2023, from https://www.merriam-webster.com/dictionary/coherence?utm_campaign=sd&utm_medium=serp&utm_source=jsonld

Merriam-Webster. (online). Life Sciences. In *Merriam-Webster.com* dictionary. Retrieved October 5, 2023, from https://www.merriam-webster.com/dictionary/life%20sciences

Michaels, S., & O'Connor, C. (2012). *Talk science primer.* University Corporation for Atmospheric Research.

Michaels, S., & O'Connor, C. (2015). "Conceptualizing teacher talk moves as tools: Professional development approaches for academically productive discussion." In Resnick, L. B., Asterhan, C. S. C., & Clarke, S. N. (Eds.). (2015). *Socializing Intelligence Through Academic Talk and Dialogue. American Educational Research Association.* http://www.jstor.org/stable/j.ctt1s474m1

Miles, M. B., Huberman, A. M., & Saldana, J. (2019). *Qualitative data analysis: A methods sourcebook* (4th ed.). Sage

Minami, M. (2021). Narrative as cultural representation: An analysis of Japanese-language learners' storytelling styles from the perspective of coherence and cohesion. *Narrative Inquiry*, *31*(1), 214-235.

Mohajan, H. K. (2018). Qualitative research methodology in social sciences and related subjects. *Journal of Economic Development, Environment and People*, *7*(1), 23-48.

Mohammed, B. A. (2021). How to write qualitative research. *International Journal of Quantitative and Qualitative Research Methods, 9*(3), 1-6.

Moreno, J. A. C., & Ussa, É. O. V. (2018). Some relationships between Biology's autonomy and the emergence of its didactics: considerations about the complexity of teaching a complex science. *Ciência and Educação (Bauru), 24*, 267-282.

Mortimer, E. F., & Scott, P. (2003). *Meaning making in secondary science classrooms.* McGraw-Hill Education.

Mortimer, E. F., & Scott, P. (2020). "Turning points in communicative approaches to science classroom discourse." In El-Hani, C., Pietrocola, M., Mortimer, E. F., & Otero, M. R. *Science education research in Latin America* (pp. 254-276). Brill.

Mudadigwa, B., & Msimanga, A. (2019). Exploring teacher pedagogical practices that help learners make connections during the teaching of reactions in aqueous solutions at senior secondary level. *African Journal of Research in Mathematics, Science and Technology Education, 23*(3), 332-343.

Munfaridah, N., Avraamidou, L., & Goedhart, M. (2021). The use of multiple representations in undergraduate physics education: What do we know and where do we go from here? *Eurasia Journal of Mathematics, Science and Technology Education*, *17*(1), em1934.

Neumann, K., & Nordine, J. (2022). "Instructional coherence and the development of student competence in physics." In Fisher, H. E., & Girwidz, R. *Physics Education* (pp. 151-173). Cham: Springer International Publishing.

Noble, H., & Smith, J. (2015). Issues of validity and reliability in qualitative research. *Evidence-based Nursing, 18*(2), 34-35.

Nordine, J., Sorge, S., Delen, I., Evans, R., Juuti, K., Lavonen, J., & Stadler, M. (2021). Promoting coherent science instruction through coherent science teacher education: A model framework for program design. *Journal of Science Teacher Education*, *32*(8), 911-933.

Nunez-Oviedo, M. C., & Clement, J. J. (2019, July). "Large scale scientific modeling practices that can organize science instruction at the unit and lesson levels." In Grogan, M., Fan, L., Kasun, G. S., Lindsay, G. A., Moore, D., Pinnegar, S., & Brown, G. T. L. *Frontiers in Education* (Vol. 4, p. 68). Frontiers Media SA.

Office of the Presidency (South Africa). (2013, November 26). *Protection of Personal Information Act, 2013 (Act no. 4 of 2013).* Government Gazette, 37067, p. 1-148.

O'Connor, C., & Michaels, S. (2019). Supporting teachers in taking up productive teacher talk moves: The long road to professional learning at scale. *International Journal of Educational Research, 97*, 166-175.

Paesani, K. (2020). Teacher professional development and online instruction: Cultivating coherence and sustainability. *Foreign Language Annals*, *53*(2), 292-297.

Penuel, W., Beauvineau, Y., DeBarger, A. H., & Moorthy, S. (2012). "Fostering teachers' use of teacher talk moves to promote productive participation in scientific practices". In Van Aalst, J., Thompson, K., Jacobson, M. J., & Reimann, P. (Eds.), *The Future of Learning: Proceedings of the 10th International Conference of the Learning Sciences (ICLS 2012) – Volume 2, Short Papers, Symposia, and Abstracts* (pp. 505-506). Sydney, NSW, Australia: International Society of the Learning Sciences.

Pereira, C. K., Nunes, B. P., Siqueira, S. W., Manrique, R., & Medeiros, J. F. (2020, July). 'A Little Knowledge is a Dangerous Thing': A method to automatically detect knowledge compartmentalization and oversimplification. In *2020 IEEE 20th International Conference on Advanced Learning Technologies (ICALT)* (pp. 140-144). IEEE.

Petty, N. J., Thomson, O. P., & Stew, G. (2012). Ready for a paradigm shift? Part 2: Introducing qualitative research methodologies and methods. *Manual Therapy, 17*(5), 378-384.

Pham, L. T. M. (2018). *Qualitative approach to research a review of advantages and disadvantages of three paradigms: Positivism, interpretivism and critical inquiry.* University of Adelaide.

Podolsky, A., Kini, T., & Darling-Hammond, L. (2019). Does teaching experience increase teacher effectiveness? A review of US research. *Journal of Professional Capital and Community, 4*(4), 286-308.

Polikoff, M. S., Porter, A. C., & Smithson, J. (2011). How well aligned are state assessments of student achievement with state content standards? *American Educational Research Journal*, *48*(4), 965-995.

Polkinghorne, D. E. (1995). Narrative configuration in qualitative analysis. *International Journal of Qualitative Studies in Education, 8*(1), 5-23.

Polly, D., Allman, B., Casto, A., Norwood, J., & Allman, B. (2018). “Sociocultural perspectives of learning.” In R E. West (Eds.), *Foundations of learning and instructional design technology.* EdTech Books. https://edtechbooks.org/lidtfoundations/sociocultural_perspectives_of_learning

Potrac, P., Jones, R. L., & Nelson, L. (2014). “Interpretivism”. In Nelson, L., Groom, R., & Potrac, P. *Research methods in sports coaching* (pp. 31-41). Routledge.

Pough, H., Bemis., W. E., McGuire, B. A., & Janis, C. M. (2022). *Vertebrate Life* (11th Ed.). Oxford University Press Inc.

Prachagool, V., Nuangchalerm, P., Subramaniam, G., & Dostál, J. (2016). Pedagogical decision making through the lens of teacher preparation program. *Journal for the Education of Gifted Young Scientists, 4*(1), 41-52.

Queiros, A., Faria, D., & Almeida, F. (2017). Strengths and limitations of qualitative. *European Journal of Education Studies, 3*(9), 369-387.

Quintão, C., Andrade, P., & Almeida, F. (2020). How to improve the validity and reliability of a case study approach? *Journal of Interdisciplinary Studies in Education, 9*(2), 264-275.

Rahman, M. S. (2020). The advantages and disadvantages of using qualitative and quantitative approaches and methods in language "testing and assessment" research: A literature review. *Journal of Education and Learning*, *6*(1), 102-112.

Rai, N., & Thapa, B. (2015). *A study on purposive sampling method in research.* Kathmandu: Kathmandu School of Law, 5.

Ralph, V. R., & Lewis, S. E. (2020). Impact of representations in assessments on student performance and equity. *Journal of Chemical Education*, *97*(3), 603-615.

Raven, P., Johnson, G., Mason, K., Losos, J., & Singer, S. (2019). Biology (12th Ed.). McGrawHill Education.

Rehman, A. A., & Alharthi, K. (2016). An introduction to research paradigms. International *Journal of Educational Investigations, 3*(8), 51-59.

Reiser, B. J., Novak, M., McGill, T. A., & Penuel, W. R. (2021). Storyline units: An instructional model to support coherence from the students' perspective. *Journal of Science Teacher Education*, *32*(7), 805-829.

Ritchie, J., Lewis, J., McNaughton Nicholls, C., & Ormston, R. (2014). *Qualitative research practice: A guide for social science learners and researchers*. Sage.

Roehrig, G. H., Dare, E. A., Ring-Whalen, E., & Wieselmann, J. R. (2021). Understanding coherence and integration in integrated STEM curriculum. *International Journal of STEM Education*, *8*, 1-21.

Rocksén, M., & Olander, C. (2017). A topical trajectory on survival: An analysis of link-making in a sequence of lessons on evolution. *Research in Science Education, 47*, 451-472.

Santos, V. D., Souza, É. F. D., Felizardo, K. R., & Vijaykumar, N. L. (2017). Analyzing the use of concept maps in computer science: A systematic mapping study. *Informatics in Education*, *16*(2), 257-288.

Sayera, A. (2019). The Communicative approach in English language teaching. *Бюллетень науки и практики, 5*(4), 471-475.

Schiering, D., Sorge, S., Keller, M. M., & Neumann, K. (2023). A proficiency model for pre-service physics teachers' pedagogical content knowledge (PCK)—What constitutes high-level PCK?. *Journal of Research in Science Teaching*, *60*(1), 136-163.

Schmidt, W., Leroi, G., Billinge, S., Lederman, L., Champagne, A., Hake, R., ... & Williams, P. (2011). Towards coherence in science instruction: a framework for science literacy. *East Lansing MI: Promoting Rigorous Outcomes in Mathematics and Science Education (PROM/SE),* Michigan State University.

Schneider, S., Krieglstein, F., Beege, M., & Rey, G. D. (2021). How organization highlighting through signaling, spatial contiguity and segmenting can influence learning with concept maps. *Computers and Education Open*, *2*, 100040.

Schuh, K. L., & Schuh, K. L. (2017). What Do They Link?. *Making Meaning by Making Connections*, 19-40.

Scott, P., & Ametller, J. (2007). Teaching science in a meaningful way: Striking a balance between 'opening up' and 'closing down' classroom talk. *School Science Review, 88*(324), 77-83.

Scott, S., & Palincsar, A. (2013). *Sociocultural theory.* The Gale Group Inc. http://drhatfield.com/theorists/resources/sociocultural_theory.pdf

Scott, P., Ametller, J., & Mortimer, E. (2010). Teaching and learning disciplinary knowledge: Developing the dialogic space for an answer when there isn't even a question. In Littleton, K., & Howe, C. *Educational Dialogues* (pp. 301-315). Routledge.

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.

Sexton, S.S. (2020). "Meaningful Learning—David P. Ausubel." In: Akpan, B., Kennedy, T.J. (eds). *Science Education in Theory and Practice.* Springer Texts in Education. Springer, Cham. https://doi.org/10.1007/978-3-030-43620-9_12

Shah, G. B. (2020). Entrepreneurship and Strategic Management: A Critical Analysis on these Paradigms' Relationship. *Pravaha, 26*(1), 73-80.

Sharma, G. (2017). Pros and cons of different sampling techniques. *International Journal of Applied Research, 3*(7), 749-752.

Shavelson, R. J., Cadwell, J., & Izu, T. (1977). Teachers' sensitivity to the reliability of information in making pedagogical decisions. *American Educational Research Journal, 14*(2), 83-97.

Sherman, D., Slawson, J., Whitton, N., & Wiemelt, J. (2010). *The little brown handbook.* Longman (pp, 42-45).

Sikorski, T. R., & Hammer, D. (2017). Looking for coherence in science curriculum. *Science Education, 101*(6), 929-943.

Škėrienė, S., & Augustinienė, A. (2018). The theoretical framework of factors influencing the pedagogical decision-making. *Pedagogika, 131*(3), 5-25.

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. (2022). Middle school science teachers' discursive purposes and talk moves in supporting students' experiments. Science & Education, 31(3), 739-785.

Staarman, J. K., & Ametller, J. (2019). "Pedagogical link-making with digital technology in science classrooms: New perspectives on connected learning." In Mercer, N., Wegerif, R., & Major, L. *The Routledge international handbook of research on dialogic education* (pp. 497-508). Routledge.

Stratton, S. J. (2021). Population research: convenience sampling strategies. *Prehospital and disaster Medicine*, *36*(4), 373-374.

Strube, P. (1994). Narrative in the science curriculum. *Research in Science Education*, *24*, 313-321.

Stuckey, H. L. (2015). The second step in data analysis: Coding qualitative research data. *Journal of Social Health and Diabetes, 3*(01), 007-010.

Stylianou-Lambert, T. (2024). “Selecting Methodologies and Methods.” In Love, A. R., & Randolph, D. *An Introductory Guide to Qualitative Research in Art Museums* (pp. 51-67). Routledge.

Sundberg, D. (2022). 6 Curriculum Coherence. *Equity, Teaching Practice and the Curriculum, 76.*

Suresh, A., Sumner, T., Huang, I., Jacobs, J., Foland, B., & Ward, W. (2018, December). *Using deep learning to automatically detect talk moves in teachers' mathematics lessons. In 2018 IEEE International Conference on Big Data (Big Data)* (pp. 5445-5447). IEEE.

Tabach, M., Hershkowitz, R., Azmon, S., & Dreyfus, T. (2020). Following the traces of teachers’ talk-moves in their students’ verbal and written responses. *International Journal of Science and Mathematics Education, 18*(3), 509-528.

Tague, J., & Czocher, J. (2016). A theoretical approach to ensuring instructional and curricular coherence in the flipped classroom model of a differential equations course. *International Journal of Research in Undergraduate Mathematics Education*, *2*, 223-245.

Tan, Y. S. M., & Amiel, J. J. (2022). Teachers learning to apply neuroscience to classroom instruction: case of professional development in British Columbia. *Professional Development in Education*, *48*(1), 70-87.

Teane, F. (2019). Language of learning and teaching as a barrier to effective implementation of caps: narratives of Grade 10 life sciences teachers in the North West Province. *Per Linguam: a Journal of Language Learning Per Linguam: Tydskrif vir Taalaanleer*, *35*(3), 95-105.

Thanh, N. C., & Thanh, T. T. (2015). The interconnection between interpretivist paradigm and qualitative methods in education. *American Journal of Educational Science, 1*(2), 24-27.

Thomas, G. (2021). *How to do your case study* (3rd Ed.). Sage.

Tubey, R. J., Rotich, J. K., & Bengat, J. K. (2015). Research paradigms: Theory and practice. *Research on Humanities and Social Sciences, 1*(25), 224-228.

Turner III, D. W., & Hagstrom-Schmidt, N. (2022). Qualitative interview design. Howdy or Hello? Technical and professional communication.

Tytler, R., & Aranda, G. (2015). Expert teachers' discursive moves in science classroom interactive talk. *International Journal of Science and Mathematics Education, 13*, 425-446.

Ummels, M. H. J., Kamp, M. J. A., De Kroon, H., & Boersma, K. T. (2015). Designing and evaluating a context-based lesson sequence promoting conceptual coherence in biology. *Journal of Biological Education*, *49*(1), 38-52.

Villegas, A. M., & Lucas, T. (2002). *Educating culturally responsive teachers: A coherent approach*. Suny Press.

Waller, S. (2015). Cohesion is still not coherence, so what is. *English Teaching in China, 6,* 31-35.

Waltzer, K., Kärkkäinen, S., & Havu-Nuutinen, S. (2023). Early childhood professionals' pedagogical decision making. *International Journal of Early Years Education,* 1-11.

Wang, J. (2020). Scrutinising the positions of students and teacher engaged in argumentation in a high school physics classroom. *International Journal of Science Education, 42*(1), 25-49.

Wang, D., Shan, D., Zheng, Y., & Chen, G. (2023, June). Teacher talk moves in k12 mathematics lessons: Automatic identification, prediction explanation, and characteristic exploration. In *International Conference on Artificial Intelligence in Education* (pp. 651-664). Cham: Springer Nature Switzerland.

Wang, X., & Zhang, Y. (2019, October). Research on fragmentation learning of college students in the internet age. In *2nd International Conference on Contemporary Education, Social Sciences and Ecological Studies (CESSES 2019)* (pp. 192-196). Atlantis Press.

Watkins, J., & Manz, E. (2022). Characterizing pedagogical decision points in sense-making conversations motivated by scientific uncertainty. *Science Education, 106*(6), 1408-1441.

Williams, K. M. (2021). *Doing research to improve teaching and learning: A guide for college and university faculty*. Routledge.

Worsnip, A. (2018). The conflict of evidence and coherence. *Philosophy and Phenomenological Research*, *96*(1), 3-44.

Yıldız-Feyzioğlu, E., & Türksever-Güleç, C. (2024). Examining talk moves of science teacher's through communicative approach. *Research in Science & Technological Education,* 1-26.

Zainal, Z. (2007). Case study as a research method. *Jurnal kemanusiaan*, *5*(1).

Zidny, R., Laraswati, A. N., & Eilks, I. (2021). A case study on students' application of chemical concepts and use of arguments in teaching on the sustainability-oriented chemistry issue of pesticides use under inclusion of different scientific worldviews. *EURASIA Journal of Mathematics, Science and Technology Education*, *17*(7), em1981.

Zohar, A. (2023). What and How to Teach in Twenty-First-Century Schools: Common Confusions Regarding Knowledge, Thinking, Pedagogy, and the Curriculum. In *Scaling-up Higher Order Thinking: Demonstrating a Paradigm for Deep Educational Change* (pp. 21-45). Cham: Springer International Publishing.

Zuckerman, S. J., Lawson, H. A., & Wilcox, K. C. (2017). Alignment and Coherence. *Innovation in Odds-Beating Schools: Exemplars for Getting Better at Getting Better, 57*.

Appendices

Appendix A: Teacher 1's interview schedule

Good day, my name is Tshilidzi Mohau Ramakoma, I am a fellow teacher at the Department of Basic Education and a Masters candidate at the University of Pretoria. The aim of my study is to explore how talk moves are used by Grade 10 Life Sciences teachers to promote pedagogical links in their classrooms. I am grateful for your cooperation with the recorded lessons and your continued cooperation will be highly appreciated. I would like to ask you a number of questions about your education, professional life and about the classroom practice I observed from your lessons. I intend to use this information to answer the research questions which will help me address the aim of my study. Your written consent of participation in this study is required. Your participation in this study is fully voluntary and you are allowed to pull out of the study at any point. The interview will take place at any time convenient to you, outside school hours and will be schedules beforehand. The interviews will be audio-recorded and your permission to record will be requested. The recordings of the interview will be transcribed, and I will email the transcripts to for verification of the text in those transcripts. Your identity will be kept anonymous i.e., your name will be replaced by a pseudonym, your gender will be omitted from the transcript and the name of your school is not mentioned in any of the documentation of my study. Only I will have access to the raw audio-recording of the interview and the audio-recording will be stored in a password protected device. Your consent will be asked to be able to use the interview transcript for my study. You do have the opportunity , at any time after the completion of the study, to enquire about the results and the findings of my study.

The following questions will be posed to you in the interview. They will include some demographic questions related to this study and questions about classroom talk and PLM. The interviews will be recorded with a voice recorder in order to ensure that an accurate version of your responses is transcribed.

A. Biographic questions

1. What qualifications do you have?
2. What is your age group? (21- 30; 31 -40; 41 -50, 51-60)
3. How long have you been teaching?
4. How long have you been teaching Life Sciences?
5. What other subjects do you teach?

B. Questions on classroom talk and PLM

1. The DBE stipulates that you should make links. What comes to mind when you hear the term linking?
2. How do you generally execute linking in you Grade 10 Life Sciences classroom?
3. While reviewing your teaching videos, I noticed that you use the board quite a lot, any reason why you opt for the use of the chalkboard so much?
4. I noticed that you rarely make links between different grades, in this case, between the grade 10 content that you taught and the work they did in Grade 8 and 9 Natural Sciences, any particular reason as to why these were not used?
5. You tend to use a lot of analogies i.e., the one of the national roads and the blood vessels, why do you use such analogies?
6. There is a particular order in which you introduced concepts in your lesson i.e., in the lesson whereby you taught learners about the circulatory system you initially talk about mammals as multicellular organisms and why they require oxygen, you then used that to draw briefly or recap on the process of respiration and then use that to introduce the circulatory system of the human body.
   a. Is there another way/order in which you could have taught this?
   b. Is this order important and why?
7. Classroom talk is a very important aspect of the teaching and learning of any subject, what comes to mind when you hear classroom talk?
8. How do you generally execute this classroom talk in your Grade 10 Life Sciences classroom?
9. I realise that you use incomplete sentences which learners complete, a lot in your classroom, why do you particularly do this in most of your lessons?

10. I also noticed that you use a question as a way to relay the following information to the class e.g., "it's a by-product, it's a waste gas. Why is it a waste? Because…". I am curious as to why you introduce information or rather impart new knowledge this way?
11. Are there any factors that can influence the way in which you make links in your lessons?
12. Are there any factors that can influence the way you use classroom talk in your classroom?

Appendix B: Teacher 2's interview schedule

Good day, my name is Tshilidzi Mohau Ramakoma, I am a fellow teacher at the Department of Basic Education and a Masters candidate at the University of Pretoria. The aim of my study is to explore how talk moves are used by Grade 10 Life Sciences teachers to promote pedagogical links in their classrooms. I am grateful for your cooperation with the recorded lessons and your continued cooperation will be highly appreciated. I would like to ask you a number of questions about your education, professional life and about the classroom practice I observed from your lessons. I intend to use this information to answer the research questions which will help me address the aim of my study. Your written consent of participation in this study is required. Your participation in this study is fully voluntary and you are allowed to pull out of the study at any point. The interview will take place at any time convenient to you, outside school hours and will be schedules beforehand. The interviews will be audio-recorded and your permission to record will be requested. The recordings of the interview will be transcribed, and I will email the transcripts to for verification of the text in those transcripts. Your identity will be kept anonymous i.e., your name will be replaced by a pseudonym, your gender will be omitted from the transcript and the name of your school is not mentioned in any of the documentation of my study. Only I will have access to the raw audio-recording of the interview and the audio-recording will be stored in a password protected device. Your consent will be asked to be able to use the interview transcript for my study. You do have the opportunity , at any time after the completion of the study, to enquire about the results and the findings of my study.

The following questions will be posed to you in the interview. They will include some demographic questions related to this study and questions about classroom talk and PLM. The interviews will be recorded with a voice recorder in order to ensure that an accurate version of your responses is transcribed.

A. Biographic questions

1. What qualifications do you have?
2. What is your age group? (21- 30; 31 -40; 41 -50, 51-60)
3. How long have you been teaching?

4. How long have you been teaching Life Sciences?
5. What other subjects do you teach?

B. Questions on classroom talk and PLM

1. The DBE stipulates that you should make links. What comes to mind when you hear the term linking?
2. How do you generally execute linking in you Grade 10 Life Sciences classroom?
3. I notice that you teach using hypothetical scenarios e.g., eating the cow for energy increase, any reason as to why you do this?
4. I picked up that you refer to certain terms and then provide their Sepedi name e.g., with decomposition, why do you do so?
5. I see that you mainly use the textbook and occasionally write terms on the board, is there any reason as to why you do this?
6. The videos I have observed display the smartboard and none of them show you using the smartboard, is there any reason why?
7. Classroom talk is a very important aspect of the teaching and learning of any subject, what comes to mind when you hear classroom talk?
8. How do you generally execute this classroom talk in your Grade 10 Life Sciences classroom?
9. I realise that you teach a section and then after that you use questions to get your learners to respond why you particularly do this in your lessons?
10. I also notice that you use incomplete sentences a lot, is there any reason why?
11. Are there any factors that can influence the way in which you make links in your lessons?
12. Are there any factors that can influence the way you use classroom talk in your classroom?

Appendix C: Teacher 3's interview schedule

Good day, my name is Tshilidzi Mohau Ramakoma, I am a fellow teacher at the Department of Basic Education and a Masters candidate at the University of Pretoria. The aim of my study is to explore how teacher talk moves are used by Grade 10 Life Sciences teachers to promote pedagogical links in their classrooms. I am grateful for your cooperation with the recorded lessons and your continued cooperation will be highly appreciated. I would like to ask you a number of questions about your education, professional life and about the classroom practice I observed from your lessons. I intend to use this information to answer the research questions which will help me address the aim of my study. Your written consent of participation in this study is required. Your participation in this study is fully voluntary and you are allowed to pull out of the study at any point. The interview will take place at any time convenient to you, outside school hours and will be schedules beforehand. The interviews will be audio-recorded and your permission to record will be requested. The recordings of the interview will be transcribed, and I will email the transcripts to for verification of the text in those transcripts. Your identity will be kept anonymous i.e., your name will be replaced by a pseudonym, your gender will be omitted from the transcript and the name of your school is not mentioned in any of the documentation of my study. Only I will have access to the raw audio-recording of the interview and the audio-recording will be stored in a password protected device. Your consent will be asked to be able to use the interview transcript for my study. You do have the opportunity , at any time after the completion of the study, to enquire about the results and the findings of my study.

The following questions will be posed to you in the interview. They will include some demographic questions related to this study and questions about classroom talk and PLM. The interviews will be recorded with a voice recorder in order to ensure that an accurate version of your responses is transcribed.

A. Biographic questions

1. What qualifications do you have?
2. What is your age group? (21- 30; 31 -40; 41 -50, 51-60)
3. How long have you been teaching?

4. How long have you been teaching Life Sciences?
5. What other subjects do you teach?

B. Questions on classroom talk and PLM

1. The DBE stipulates that you should make links. What comes to mind when you hear the term linking?
2. How do you generally execute linking in you Grade 10 Life Sciences classroom?
3. While reviewing your teaching videos, I noticed that you make use of the whiteboard quite often? Is there any reason why you opt for the sue of the whiteboard?
4. I also noticed that you provided your learners with a set of notes which your urged them to follow through on in your lesson, why do you opt for their use?
5. I notice that you 'link' every concept to learners' real-life e.g., the orange intake during Covid-19 and your learners related it to the function of boosting immunity and Vitamin C, any reason as to why you do this a lot?
6. I also noticed that your remind learners of what you said before you relay the relevant piece of information in the lesson, is there any reason why you do this?
7. You also link the work the learners are currently busy with to future grades. Why do you do this?
8. Why do you not use the smartboard? How often do you use it? Why?
9. Classroom talk is a very important aspect of the teaching and learning of any subject, what comes to mind when you hear classroom talk?
10. How do you generally execute this classroom talk in your Grade 10 Life Sciences classroom?
11. I realise that you use incomplete sentences which learners complete, a lot in your classroom, why do you particularly do this in most of your lessons?
12. I noticed that you use incomplete sentences, which learners complete a lot in your classroom, why do you particularly do this in most of your lessons?
13. In noticed that you pitch a real-life idea to the learners in order to get them to answer your questions e.g., the role of Vitamin c, which you relayed back to the encouragement of orange eating during the pandemic. I am curious as to why you do this.

14. I realised that you tend to ask learners questions that revolve around the definitions of certain terms while explaining concepts. Why do you do this?
15. Are there any factors that can influence the way in which you make links in your lessons?
16. Are there any factors that can influence the way you use classroom talk in your classroom?

Appendix D: Example of an analysed lesson transcript

Teacher 3 transcript

Lesson 1

1	Teacher	Plant kingdom. You don't have something called kingdom bryophytes (writes on board). This is wrong. Normally, they're said to be groups of divisions that fall under kingdom plantae (points to board). So, we have four groups. The first one is bryophytes (writes on board). Example is what?
2	Learners	Mosses
3	Teacher	Mosses (writes it on the board), the bryophytes are said to be thallus plants. Thallus (writes it on board). Bryophytes examples are said to be your mosses, right? (points to board). They are said to be thallus (points to board). What do we mean when we say they are thallus plants? We mean that they do not have true roots (writes it on board). They do not have true roots, stems and leaves. And then we also have the pteridophytes. An example of pteridophytes is what is you fern land (writes on board). But this one, they are not thallus (writes on board). They reproduce, hello! The pteridophytes examples is your ferns, right?
4	Learners	Yes
5	Teacher	They are not thallus; they reproduce by means of spores (writes on board). Okay, then we go to the angiosperms. Angiosperms are said to be your flowering plants (writes on board). Do you know different types of flowering plants? Examples, the one that you get in your garden?
6	Learners	A rose
7	Teacher	A rose is a flowering plant (writes on board). And then what else do you know? Another example falls under a flower that falls under angiosperms.
8	Learner A	That would find a peach tree.
9	Teacher	Peach tree (writes it down). Okay, angiosperms most of the time they have seed, right?
10	Learners	Yes
11	Teacher	But their seeds are not naked. They are actually enclosed inside a fruit (indicates this by using hand gestures). Fr example, your apple. You eat the apple at the end, find a seed at the end. They were introduced inside a fruit. Okay, but it is what an angio...
12	Learners	Sperm
13	Teacher	It's a flowering plant before it becomes a fruit. It starts by being like a flower. Then the agents of pollination. Your bees, your weave are the ones that are going to spread along by pollen spray to the female part, which is what? An ovule and an ovary. You will learn more about those things when you go to Grade?
14	Learners	Eleven
15	Teacher	How fertilisation takes place within the plant. Okay, for now, what you need to know is just to know those groups, know their examples (points to board) and then know the characteristics (writes on board). Do you understand?
16	Learners	Yes

17	Teacher	So, the consist of seeds enclosed inside a fruit (writes a board). Okay, then the last one is what? Gymno? (points to board)
18	Learners	Sperms
19	Teacher	Gymnosperms. Example of gymnosperm (writes on board). Your conifers (writes on board). And then your cycads (writes on board). Those most of the time are the cone-bearing plants (writes on board). They also have what? Seeds, but their seeds are what?
20	Learners and Teacher	Naked
21	Teacher	You are able to see them, seeds are?
22	Learners	Naked
23	Teacher	Okay, then characteristics (writes on board). Characteristics of all the groups. This one I have given you again on your notes. We are going to look at those notes in looking at the characteristics of all these groups (points to them on the board). Starting with bryophytes, the pteridophytes, angiosperms and the? (pointing at the board)
24	Learners	Gymnosperms
25	Teacher	Okay, can you go to your notes? (refers to the set of notes provided to learners): Just below the rhizome, you see the smaller adventitious root line?
26	Learners	Yes
27	Teacher	You call those one the adventitious roots. And then just above, you find the young fern leaf. It's not yet mature. Again. It's said to be young and then you get your mature compound. The reason why it's said to be compound, it's because they share branches again (draws on board), like, can you see that?
28	Learners	Yes
29	Teacher	So, a fern plant consists of compound leaves. There are many leaves on one stalk (indicates this by using hand gestures). Okay. General characteristics, number one, all the groups are said to be multicellular and ?
30	Learners	Complex
31	Teacher	We are speaking of general characteristics for all the groups. And then number two, plants have true nuclei and are therefore what? Eukaryotic. When they have a true nucleus, we say they are what?
32	Learners	Eukaryotes
33	Teacher	But if they do not have a definite nucleus, they are said to be what? If there is no true nucleus, we call them what? Raise up your hand. What do we call them, Learner B? Organisms that don't have a true nucleus what do we call them
34	Learner C	Prokaryotes
35	Teacher	Proka...
36	Learners	...ryotes
37	Teacher	Can we continue? Bullet number three says plants have cell...
38	Learners	Walls
39	Teacher	Of value. They do have cell walls, right?
40	Learners	Yes
41	Teacher	Most plants are said to be autotrophic by now, you know? What does autotrophic mean? It means that they are able to produce their own ?
42	Learners	Food

43 Teacher	We have plants that reproduce asexually by means of spored. Is which group that I said reproduces by spored here (points to board)
44 Learners	Number 3
45 Teacher	Which group is it? Is it bryophytes (points to board), pteridophytes (points to board), angiosperms (points to board) or gymnosperms (point to board)? Raise up your hands
46 Learners	Pteridophytes
47 Teacher	Who are saying the pteridophytes? Raise up your hands.
48 Learners	(Raise their hands)
49 Teacher	Oh! Those are the people that I'm teaching, then it means when I talk, I'm talking to those people that have raised them up there. Whatever that you're saying is wrong. The pteridophytes they reproduce by means of?
50 Learners	Spores
51 Teacher	And when they reproduce by means of spores. We call that, reproduction sexual or asexual?
52 Some learners	Sexual
53 Teacher	Sexual or asexual?
54 Learners	Asexual
55 Teacher	Asexual not sexual, because there is no involvement of gametes, asexual its only spores involved. Okay, angiosperms and gymnosperms (writes on board), they reproduce sexually because we get what? Gametes. When we speak of gametes (writes on board – draws a diagram). Guys, when we speak of gametes, you get the male part (writes on the board). You also get the female part (writes on board). Again, the male part will consist of pollen grain. And then an anther also. The female part will consist of what? An ovule and then also what? A stigma. The fruit before it becomes a mature fruit. Hello! A fruit before it becomes a mature fruit. The male part is going to deposit what? The pollen grain inside the stigma, and then it goes to an ovule, after an ovule, goes to the?
56 Learners	Ovary
57 Teacher	Where fertilisation is ging to take place and therefore, now a fruit is going to go from young to be a mature fruit. Perekisi (Sesotho term for a peach), a peach, doesn't start by being a mature peach. It starts as young, then it grows, it grows until it becomes sweet and we're able to eat them. So, here there's an involvement of what? Gametes. And we say sexual?
58 Learners	Reproduction
59 Teacher	Do you understand?
60 Learners	Yes
61 Teacher	Plants also behave like us (wipes board). (writes Kingdom Animalia on the whiteboard) ok. Guys, Kingdom Animalia. It consists of different species. The kingdom animalia is made up of phylums (writes it on board). Remember we said in Kingdom Plantae we find what? Groups and divi?
62 Learners	Divisions?
63 Teacher	But on kingdom animalia, you find phylums (writes on board). Next, so the phylums that you're going to learn about its 9, we have 9

		phylums (writes on board). But when you go to grade 11, you're going to do six phylums (indicates 6 by using fingers). Do you hear me?
64	Learners	Yes
65	Teacher	When you go to grade 11, you're going to do six phylums, but now you need to know all the phylums you have. How many?
66	Learners	Nine
67	Teacher	This is a part of zoology. If you have interest in learning what bachelor of science in Zoology. So, number one (writes on the board). Phylum Echinodermata (continues to write the rest of the phyla on the board). Phylum Platyhelminthes (writes in on the board). It doesn't matter how I wrote them. What matters is you need to know all of the nine phylum. The phylum Mollusca (writes on the board). Okay, and then 8, it's phylum? What? Phylum Chordata. You are human being; you fall under phylum Chordata (writes it on board). Nine. The last one is phylum Nematoda (writes it on board). Guys, all these phylums, they fall under kingdom?
68	Learners	Animalia
69	Teacher	We said when start this topic, all organisms are classified according to their different chara…
70	Learners	…teristics
71	Teacher	Do you remember?
72	Learners	Yes
73	Teacher	So, these animals were also classified according to their different?
74	Learners	Characteristics
75	Teacher	Some have two legs. Again, some have four legs, some are insects
76	Learner A	Some have fins
77	Teacher	Some are invertebrates and some are?
78	Learners	Vertebrates
79	Teacher	Remember, we have animals that are said t be invertebrates and some are said to be vertebrates. We have insects that also have what?
80	Learners	A backbone
81	Teacher	Your cockroach has a backbone. Your cockroach at home. Did you know that a cockroach has a backbone? Guys, I'm giving you homework, go and google and search if a lepena (Sesotho term for cockroach). After you step on a cockroach does it die? (all said in Sesotho)
82	Some learners	Yes
	Some learners	No
83	Teacher	Does a cockroach die immediately? When you DOOM a cockroach does it die immediately?
84	Learners	No
85	Teacher	It takes time. Okay, guys can we go to your notes and check the examples of each phylum. Hello. Before we check those phylums, we need to master how to pronounce those phylums. Hello! Hello! Hello! Hello! I said to you under kingdom animalia (points to it written on board), we have animals that are said to have invertebrates and?
86	Learners	Vertebrates
87	Teacher	What are invertebrates?
88	Learners	Animals does not have backbone.

89	Teacher	Animals that do not have a vertebrae column. Hello, invertebrates (writes it on the board). Vertebrae column (pints to the board). And then vertebrates are animals that have what? Vertebrae column. Which is known as what?
90	Learners	Backbone
91	Teacher	Ok, can you check that table (refers to table on the notes provided to learners). Check out that table. The one that speaks of kingdom animalia. Okay, on the first page it says the kingdom animalia is divided into approximately 35 phyla. The nine most important are shown below. I said for your level of grade. Hello! I said for your level of grade, I said for your level of grade, which is grade 10. Yu are doing nine phylums. And then when you go to grade 11, you're only going to do?
92	Learners and Teacher	Six
93	Teacher	So, number one, it's said to be phylum Polifera. Those animals, you find them in water. Example, it's what? Sponges. They are actually aquatic. Do you know sponges?
94	Learners	No
95	Teacher	Do you know sponges?
96	Learners	No
97	Teacher	Okay, then you get another phylum. Which is what? Phylum Cnidaria. Phylum Cnidaria. Example is your jellyfish. Do you know the jellyfish?
98	Learners	Yes
99	Teacher	And then your bluebottles, and then your corals, and then your sea anemones. Guys, if you didn't know those species by pictures, d yourself a nice favour. Go to YouTube, look for a video that talks about animal diversity. Then watch that video, it will explain everything. You will see the pictures; you will see everything. Guys, some people are talking while I'm teaching. Hello! Yes, Learner B?
101	Learner B	Teacher, isn't that in plants in order to have plants we need to have a moving animal?
102	Teacher	In order to have fruit. Not to have plants. In order to have fruits. In order to have fruits. Yes, agents of pollination. Which are your bees, your wean or your birds. They play around in making sure that we have a success. In what?
103	Learners	Fertilisation
104	Teacher	Yes. So, what is your question?
105	Learner B	Soo , my question is what kingdom d sperms fall under? Cause in kingdom Plantae?
106	Teacher	No, n, no, no. Sperms do not fall under any kingdom. I did not speak of sperms. Hello. I did not speak of sperm because I'm talking about flowers. I spoke about pollen and ovary. I didn't speak of sperms because you find them in human beings. Doesn't include sperms under nay kingdoms. You find them in animals and human bodies. You find them only in the males, the females don't have what? A sperm. It means all the animals that are male, some have sperm, and some do not reproduce by sperm. Okay can we continue. You get your phylum. Another phylum is known as what? Platyhelminthes

107	Learners and teacher	Platy- hel- minthes
108	Teacher	For short spelling purposes, you will never go wrong. When you pronounce things correctly according to how they are pronounced. Platy, you divide it. Hel- minthes Okay, example. There is a phylum that is made up of your flatworms do you know the flat worms? PIIM
109	Learners	No
110	Teacher	Okay, example is your planaria. It's mostly found in water. And then your tapeworm. Then you get phylum Nematoda, Nematoda. You find your roundworms. And then phylum Annelida, which is what your earth worms, sea worms and leeches. Do you know leeches?
111	Some learners	No
112	Some learners	Yes
113	Teacher	You find them in water. Earthworm, most of the time for us, we see it when it's too much rain. And then you get your phylum Annelida. Oh, Annelida, we have done it. You get your phylum Mollusca, snails. Hello! Snails fall under phylum Mollusca. You are familiar with snails, right? PIIM LIIM
114	Learners	Yes. ARM, CRM & LCRM
115	Teacher	Yes, snail isn't harmful, guys. You can take it, put it on your finger, see how it moves. That jelly will be left here. That jelly sometimes it is the one that they make certain skin products and then you get your oysters, we eat them. Do you eat oysters? PIIM IIM
116	Some learners	Yes
117	Some learners	No
118	Teacher	And the you get mussels. You don't eat oyster? Okay guys, another phylum Echinodermata.

Appendix E: Result analysis instrument for Video data

Result analysis instrument for Lessons

Teacher:

Lesson:

Priori code list:

Pedagogical links		Teacher talk moves
Use of analogies		Launch initiating moves
Usage of different scales and levels of explaining		
Connecting various points within a lesson	↔	Literal initiating moves
Using different forms of representation		
Connecting different scientific concepts to each other		Provides information initiating moves
Connecting every day and scientific explanations		
Connecting occurrences in real-life with scientific explanations		Repeat rejoinder moves
Connecting consecutive activities within a lesson		Uptake rejoinder moves
Connecting various points in a lesson sequence		
Referring to different teaching and learning points within different parts of the science curriculum		Connection rejoinder moves

PLM priori code	Does it have a corresponding TTM priori code?	Corresponding TTM priori code	Line numbers in lesson sequence

Appendix F: An example of a filled-out result analysis instrument for Video data

Result analysis instrument for Lessons

Teacher: 3

Lesson: 1

Priori code list:

Pedagogical links	Teacher talk moves
Use of analogies	Launch initiating moves
Usage of different scales and levels of explaining	Literal initiating moves
Connecting various points within a lesson.	Provides information initiating moves
Using different forms of representation.	Repeat rejoinder moves
Connecting different scientific concepts to each other.	Uptake rejoinder moves
Connecting every day and scientific explanations	Connection rejoinder moves
Connecting occurrences in real-life with scientific explanations.	
Connecting consecutive activities within a lesson	
Connecting various points in a lesson sequence.	
Referring to different teaching and learning points within different parts of the science curriculum.	

PLM priori code	Does it have a corresponding TTM priori code?	Corresponding TTM priori code	Line numbers in lesson sequence
Using different forms of representation	YES	PIIM	1
	YES	PIIM	1
"	YES	PIIM	1
	YES	PIIM	3
"	YES	PIIM	3
	YES	PIIM	3
"	YES	PIIM	3
	YES	PIIM	3
	YES	PIIM	3
"	YES	PIIM	3
	YES	PIIM	5
	YES	PIIM	5

''	YES	PIIM	25
	YES	PIIM	27
	YES	PIIM	29
Using diff forms of representations	YES	PIIM	7
	YES	PIIM	9
''	YES	PIIM	11
	YES	PIIM	15
''	YES	PIIM	15
	YES	PIIM	17
''	YES	PIIM	17
	YES	PIIM	19
''	YES	PIIM	19
	YES	PIIM	19
''	YES	PIIM	19
	YES	PIIM	28
	YES	PIIM	23
	YES	PIIM	23

''	YES	PIIM	67
	YES	PIIM	67
	YES	PIIM	67
Using diff forms of representation	YES	PIIM	43
	YES	PIIM	45
''	YES	PIIM	45
	YES	PIIM	45
''	YES	PIIM	45
	YES	PIIM	55
''	YES	PIIM	55
	YES	PIIM	55
''	YES	PIIM	57
	YES	PIIM	61
''	YES	PIIM	61
	YES	PIIM	63
	YES	PIIM	63
	YES	PIIM	63
	YES	PIIM	67

CONSECUTIVE ACTS	YES	PIIM	61
	YES	PIIM	63
"	YES	PIIM	67
	YES	PIIM	67
Using diff forms of representation	YES	PIIM	67
	YES	PIIM	67
"	YES	PIIM	81
	YES	LIIM	81
"	YES	PIIM	85
	YES	PIIM	85
"	YES	PIIM	89
	YES	PIIM	89
"	YES	PIIM.	91
CONSECUTIVE ACT	YES	PIIM	1
"	YES	PIIM	23
	YES	PIIM	23
	YES	PIIM	29
	YES	PIIM	31
	YES	LIIM	37

SCIENTIFIC EXPLANATIONS	YES	LAIM	5-7
	YES	PIIM & LIIM	11-12
	YES	PIIM	57
CONSECUTIVE ACTS	YES	PIIM	93
	YES	PIIM	106
SCIENTIFIC CONCEPTS	YES	PIIM	3
	YES	PIIM	29
"	YES	PIIM, LIIM, PIIM + LIIM	31-34
	YES	PIIM, LIIM, PIIM&LIIM	41-42.
"	YES	LIIM	51
	YES	PIIM + PIIM	54-55
"	YES	PIIM, LIIM & PIIM	61
	YES	PIIM	79
"	YES	PIIM	106
	YES	PIIM	106
SCIENTIFIC EXPLANATIONS	YES	PIIM	67
	YES	PIIM + LIIM	81

SCIENTIFIC EXPLANATIONS	YES	LIIM	81
	YES	LIIM, LIIM	83–85
	YES	PIIM	113
"	YES	LIIM, PEM, CFM & LLCM	113–115
	YES	PIIM & LIIM	115
SCALES & LEVELS	YES	PIIM	11
	YES	PIIM	27
"	YES	PIIM	29
	YES	PIIM	57
"	YES	PIIM	57
	YES	LIIM, LIIM, PIIM, PIIM	73 – 78
"	YES	PIIM	108
SCIENCE CURRICULUM	YES	LIIM & PIIM	13
"	YES	PIIM	63
	YES	PIIM	65
	YES	PIIM	67
	YES	PIIM	91

VARIOUS POINTS	YES	LIIM	43
		LIIM & PIIM	61–62
		LIIM & PIIM	85
		PIIM	91
		PIIM	105
	YES	PIIM	105
		LIIM & LIIM	88
OCCURENCES		LIIM	69–72
LESSON SEQUENCE	YES	PIIM	79
	YES		
	YES		

Appendix G: Permission obtained from the Department of Basic Education to carry out study

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

GDE RESEARCH APPROVAL LETTER

Date:	**06 September 2023**
Validity of Research Approval:	**08 February 2023– 30 September 2023** **2023/395**
Name of Researcher:	**Ramakoma TM**
Address of Researcher:	**2257 Candlewood Crescent**
	Ebony Park Extension 5
Telephone Number:	**064 9803673**
Email address:	**U18122303@tuks.co.za**
Research Topic:	**Exploring pedagogical link-making and teacher talk moves in Grade 10 Life Sciences classrooms**
Name of University:	**University of Pretoria**
Type of qualification	**Masters**
Number and type of schools:	**10 Secondary Schools**
District/s/HO	**Ekurhuleni North, Johannesburg East**

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.

06/09/2023

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

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 H: Permission obtained from the University of Pretoria to carry out the study

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Make today matter
www.up.ac.za

FACULTY OF EDUCATION
Ethics Committee

Amendment

21 August 2023

Dear Miss TM Ramakoma

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

Ethics Protocol No:	**EDU09823 KHOZA 23-01**
Principal Investigator:	**Miss TM Ramakoma**
Student/Staff No:	**18122303**
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 3-63, Level 3, Aldoel Building
University of Pretoria, Private Bag X20
Hatfield 0028, South Africa
Tel +27 (0)12 420 5656
Email edu.ethicsadmin@up.ac.za
www.up.ac.za

Faculty of Education
Fakulteit Opvoedkunde
Lefapha la Thuto

Appendix I: Principal's consent letter

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

LETTER OF INFORMED CONSENT: PRINCIPAL

Groenkloof Campus

Pretoria

0002

14 July 2023

Dear Principal

I am a Masters candidate at the faculty of Education in the University of Pretoria (South Africa) working under the supervision of Dr Climant Khoza and Prof Rian de Villiers from the Department of Science, Mathematics and Technology education. I am conducting a research study titled "*exploring pedagogical link-making and teacher talk moves in Grade 10 Life Sciences classrooms*." In this study I intend to explore how teacher talk moves are used by Grade 10 Life Sciences teachers to promote pedagogical links in their classrooms.

To carry out this study, I need to collect data at numerous schools in Gauteng, particularly schools within the Ekurhuleni North and the Johannesburg East district. Your school is included in this cohort of schools, as such, I am humbly requesting your permission to carry out my research study at your school. The findings from this study will assist in equipping Life Sciences teachers with the necessary skills they require in order to successfully make links in their classrooms as stipulated by the Life Sciences Curriculum and Assessment Policy Statement. The departments of Basic and Higher Education will also benefit from this study as the findings will be useful in the improvement of training programmes for Life Sciences teachers.

There are two aspects to this research, an interview (using an interview schedule) and Video data. I seek authorization to record the Life Sciences lessons of one Grade 10 Life Sciences teacher and also to interview that particular teacher. The teacher in question would be required to record between 5 – 10 of their Grade 10 Life Sciences lessons and relay them to me. After the analysis of those lessons, I would then interview that teacher for about 60 minutes. The interview schedule consists of about 13 questions and will be conducted after the official school hours. These interviews will be audio-recorded. The video-recordings of the lessons along with the audio-recordings of the interviews will be transcribed into data and the analyzed. Confidentiality and anonymity will be guaranteed always by using pseudonyms to the participants during the transcription phase. No participant names or personal information will be reported in my findings. The data obtained from this study will be interpreted through codes and common themes, this would ensure that this study is credible thus assuring the quality of the research study.

It is important to note that the competencies of the Grade 10 Life Sciences teachers will not be commented on, this study seeks to look at how particular phenomena are naturally carried out in life Sciences classrooms and not necessary on the teachers' competency in teaching the subject. The finalized findings will be conveyed to you upon request, but identifying information will not be released to you or any other party. The transcripts from both the video- and audio-recordings will be treated with the outmost confidentiality by restricting access only to myself, the supervisor and co-supervisor.

The data gathered will only be used for academic purposes and may be published in academic journals. A summary of the findings will be provided upon request. The data collected is the intellectual property of the University of Pretoria and where applicable, project funders, as such, I am also requesting permission to further use this Data obtained from this study in future research. the privacy and confidentiality applicable to this study will be binding also in future research studies.

There will be no interruption of teaching activities and no tuition time will be lost. Voluntary participation is encouraged as such there will be no incentives of any sort awarded to the participants to avoid bias. All the participating individuals will be asked to sign a consent/ assent letter, and all the participation in this research study would be voluntary. No deception and 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 drive.

Although participation in this study is voluntary, the participation of schools in the Ekurhuleni North and Johannesburg East districts is essential for the success if this research study. If you agree to grant my research study permission, I would highly appreciate the completion of the accompanying consent letter. Should you have any further enquiries, you are more than welcome to get in contact with me or my supervisors.

Yours sincerely

Ms Tshilidzi Mohau Ramakoma
Researcher
u18122303@tuks.co.za
064 980 3673

____________________________ _______________________

Signature of the researcher Date

____________________________ _______________________

Signature of the supervisor Date

____________________________ _______________________

Signature of the co-supervisor Date

Contact details:

Researcher	Supervisor	Co-supervisor
Ms Tshilidzi Mohau Ramakoma	Dr C. Khoza	Prof J.J.R. de Villiers
u18122303@tuks.co.za	climant.khoza@up.ac.za	rian.devilliers@up.ac.za
0649803673	0124205734	0124205529

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

Appendix J: Teacher's consent form

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

LETTER OF INFORMED CONSENT: TEACHERS

Groenkloof Campus
Pretoria
0002
14 July 2023

Dear Teacher

I am a Masters candidate at the faculty of Education in the University of Pretoria (South Africa) working under the supervision of Dr Climant Khoza and Prof Rian de Villiers from the Department of Science, Mathematics and Technology education. I am conducting a research study titled "*exploring pedagogical link-making and teacher talk moves in Grade 10 Life Sciences classrooms*." In this study I intend to explore how teacher talk moves are used by Grade 10 Life Sciences teachers to promote pedagogical links in their classrooms.

To carry out this study, I need to collect data at numerous schools in Gauteng, particularly schools within the Ekurhuleni North and the Johannesburg East district. Your school is included in this cohort of schools, as such, I am humbly requesting your permission to observe the pedagogical links you make while teaching and the teacher talk moves you use to make them in your Grade 10 Life Sciences lessons. The findings from this study will assist in equipping Life Sciences teachers with the necessary skills they require in order to successfully make links in their classrooms as stipulated by the Life Sciences Curriculum and Assessment Policy Statement. The departments of Basic and Higher Education will also benefit from this study as the findings will be useful in the improvement of training programmes for Life Sciences teachers.

There are two aspects to this research, an interview (using an interview schedule) and Video data. I seek authorization to record your Life Sciences lessons and also to interview you. You would be required to record between 5 – 10 of your Grade 10 Life

Sciences lessons and relay them to me. After the analysis of those lessons, I would then interview you for about 60 minutes. The interview schedule consists of about 13 questions and will be conducted after the official school hours. These interviews will be audio-recorded. The video-recordings of the lessons along with the audio-recordings of the interviews will be transcribed into data and the analyzed. Confidentiality and anonymity will be guaranteed always by using pseudonyms to the participants during the transcription phase. No participant names or personal information will be reported in my findings. The data obtained from this study will be interpreted through codes and common themes, this would ensure that this study is credible thus assuring the quality of the research study.

It is important to note that your competencies as a Grade 10 Life Sciences teacher will not be commented on, this study seeks to look at how particular phenomena are naturally carried out in life Sciences classrooms and not necessary on the teachers' competency in teaching the subject. The finalized findings will be conveyed to you upon request, but identifying information will not be released to you or any other party. The transcripts from both the video- and audio-recordings will be treated with the outmost confidentiality by restricting access only to myself, the supervisor and co-supervisor.

The data gathered will only be used for academic purposes and may be published in academic journals. A summary of the findings will be provided upon request. The data collected is the intellectual property of the University of Pretoria and where applicable, project funders, as such, I am also requesting permission to further use this Data obtained from this study in future research. the privacy and confidentiality applicable to this study will be binding also in future research studies.

There will be no interruption of teaching activities and no tuition time will be lost. Voluntary participation is encouraged as such there will be no incentives of any sort awarded to the participants to avoid bias. There will also be no implication for academic assessments for participation or non-participation. All the participating individuals will be asked to sign a consent/ assent letter, and all the participation in this research study would be voluntary. No deception and 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 drive.

Although participation in this study is voluntary, the participation of schools in the Ekurhuleni North and Johannesburg East districts is essential for the success if this research study. If you agree to grant my research study permission, I would highly appreciate the completion of the accompanying consent letter. Should you have any further enquiries, you are more than welcome to get in contact with me or my supervisors.

Yours sincerely

Ms Tshilidzi Mohau Ramakoma
Researcher
u18122303@tuks.co.za
064 980 3673

____________________________ ______________________

Signature of the researcher Date

____________________________ ______________________

Signature of the supervisor Date

____________________________ ______________________

Signature of the co-supervisor Date

Contact details:

Researcher Supervisor Co-supervisor

Ms Tshilidzi Mohau Ramakoma Dr C. Khoza Prof J.J.R. de Villiers
u18122303@tuks.co.za climant.khoza@up.ac.za rian.devilliers@up.ac.za
0649803673 0124205734 0124205529

DECLARATION OF CONSENT

Signing on this page means that you grant permission for your participation 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

Appendix K: Learners' assent form

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

LETTER OF INFORMED ASSENT: LEARNERS

Groenkloof Campus
Pretoria
0002
14 July 2023

Dear Learner

Why am I here?

I am a Masters candidate at the faculty of Education in the University of Pretoria (South Africa) working under the supervision of Dr Climant Khoza and Prof Rian de Villiers from the Department of Science, Mathematics and Technology education. I am conducting a research study titled "*exploring pedagogical link-making and teacher talk moves in Grade 10 Life Sciences classrooms*." In this study I intend to explore how teacher talk moves are used by your Life Sciences teachers to promote pedagogical links in their classrooms.

What will my involvement be?

I will observe video-recordings of the lessons taught by your Life Sciences teacher. The lessons will take place during normal school hours in the normal Life Sciences classroom. Observations will be done for about 5 – 10 lessons. The teachers will be teaching about the topic, environmental studies, biodiversity and classification, covered in the third term of the South African school year, and ask question where necessary provide feedback. This may result in you responding to certain questions and some interaction may occur as the topic is taught.

The lessons will be video-recorded by your teacher 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 participated in this study will be treated with confidentiality and will not be disclosed. Instead, codes for the schools will be used and the names of teachers and learners will be replaced with pseudonyms in spoken and written reports. Therefore, there is no need to be concern about what others may think about your responses in class. The recordings will be treated confidentially. Only my supervisors and I will have access to the recordings and transcripts. To ensure that those recordings and transcripts will only be accessible to me and my supervisors, they will be stored in a password protected device.

Additionally, it is also important to note that no tuition time will be lost, the normal teaching activities will not be interrupted, 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. You will not be exposed to deception at any point of the study.

Finally, we 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 intellectual property of the University of Pretoria, and where relevant, project funders. The confidentiality and privacy applicable in 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 me?

The findings of this research project might help improve the skills of your Life Sciences teacher which can only improve your learning experiences. This improvement will not be instant, however, 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, after school hours, you are more than welcome to contact me via text message or phone call (Tshilidzi Mohau Ramakoma) at 0649803673 or ask to see me at your school or even ask my supervisors using the contacts provided below.

Do my parents/ guardians know about this project?

The project was explained to parents/ guardian 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 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 in this 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 Tshilidzi Mohau Ramakoma
Researcher
u18122303@tuks.co.za
0649803673

____________________________ ________________________

Signature of the researcher Date

____________________________ ________________________

Signature of the supervisor Date

_______________________________ _________________________

Signature of the co-supervisor Date

Contact details:

Researcher	Supervisor	Co-supervisor
Ms Tshilidzi Mohau Ramakoma	Dr C. Khoza	Prof J.J.R. de Villiers
u18122303@tuks.co.za	climant.khoza@up.ac.za	rian.devilliers@up.ac.za
0649803673	0124205734	0124205529

DECLARATION OF ASSENT

Signing on this page means that you I 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 have to inform the Life Sciences teacher or myself.

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

Appendix L: Parents' consent form

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

LETTER OF INFORMED CONSENT: PARENT

Groenkloof Campus

Pretoria

0002

14 July 2023

Dear Parent/ Guardian

I would like to invite your child ______________________________ to participate in a research study. In order to decide whether or not to participate in this research study you should know enough about this study, its risks and its benefits in order to make an informed decision. You can decide if you want to child to participate in this study once you understand what this study is about. If that is the case, you will be required to sign this consent form, to give permission for your child to be part of this study.

I am a Masters candidate at the faculty of Education in the University of Pretoria (South Africa) working under the supervision of Dr Climant Khoza and Prof Rian de Villiers from the Department of Science, Mathematics and Technology education. I am conducting a research study titled "*exploring pedagogical link-making and teacher talk moves in Grade 10 Life Sciences classrooms*." In this study I intend to explore how teacher talk moves are used by Grade 10 Life Sciences teachers to promote pedagogical links in their classrooms.

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

I will observe video-recordings of the lessons taught by your child's Life Sciences teacher. The lessons will take place during normal school hours in the normal Life

Sciences classroom. Observations will be done for about 5 – 10 lessons. The teachers will be teaching about the topic, environmental studies, biodiversity and classification, covered in the third term of the South African school year, and ask question where necessary provide feedback. This may result in your child responding to certain questions and some interaction may occur as the topic is 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 participated in this study will be treated with confidentiality and will not be disclosed. Instead, codes for the schools will be used and the names of teachers and learners will be replaced with pseudonyms in spoken and written reports. Therefore, there is no need to be concern about what others may think about your child's responses in class. The recordings will be treated confidentially. Only my supervisors and I will have access to the recordings and transcripts. To ensure that those recordings and transcripts will only be accessible to me and my supervisors, they will be stored in a password protected device.

Additionally, it is also important to note that no tuition time will be lost, the normal teaching activities will not be interrupted, 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 of the study.

Finally, we 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 intellectual property of the University of Pretoria, and where relevant, project funders. The confidentiality and privacy applicable in 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 the skills of your child's Life Sciences teacher which can only improve your child's learning experiences. This improvement will not be instant, however, 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, after school hours, you are more than welcome to contact me via text message or phone call (Tshilidzi Mohau Ramakoma) at 0649803673 or ask to see me at your school or even ask my supervisors using the contacts 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 you will first have to provide permission through a signed consent letter 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 decide if they want to be part of the project or not.

What will happen to the data collected?

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

Yours sincerely

Ms Tshilidzi Mohau Ramakoma
Researcher
u18122303@tuks.co.za

0649803673

__________________________ _____________________

Signature of the researcher Date

__________________________ _____________________

Signature of the supervisor Date

__________________________ _____________________

Signature of the co-supervisor Date

Contact details:

Researcher	Supervisor	Co-supervisor
Ms Tshilidzi Mohau Ramakoma	Dr C. Khoza	Prof J.J.R. de Villiers
u18122303@tuks.co.za	climant.khoza@up.ac.za	rian.devilliers@up.ac.za
0649803673	0124205734	0124205529

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 have to 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