Ascertaining what Grade 8 Natural Sciences learners already know: a starting point for meaningful learning

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Abstract

Science classrooms are places where learners are taught to understand the world we live in. Having lived in and experienced the world, grade 8 learners enter the science classroom with some knowledge of this world. From a sociocultural perspective, if learners are to make sense of new concepts, using the tools of language, learners must link what they already know, to new concepts. However, this is not easily achieved, as learners come to class with a myriad of ways of understanding science concepts. My study explored how four teachers, working in a suburban high school in Gauteng, interacted with learner prior knowledge (LPK) over two years when teachers taught the topics effects of electric current and light, to 13 and 14 year old learners in grade 8.

Working within an interpretivist research paradigm, my qualitative study used an action research design, to investigate, how do interactions concerned with exploring LPK change, as teachers participate in a professional learning community (PLC) focused on encouraging learners to make their knowledge explicit? Data collection methods included using semi-structured interviews, video recordings of lessons, and audio recordings of lessons and PLC meetings. Recordings from lessons were analysed using Mortimer and Scott's framework: analysing meaning making interactions in science classrooms, particularly the pattern of interaction that happened and the communicative approach teachers used. Pimental and Mc Neill's coding schemes were used to code learner responses and teacher moves.

Initially teachers interacted with LPK, mostly from formal instruction. None of the teachers planned activities to challenge alternative conceptions learners have. When interacting with LPK in their baseline lessons, teachers tended to use the triadic IRE pattern of interaction. Questions (I) were of low order, learners would respond (R) in single words or phrases, and the teacher evaluated (E) the learner response. The interactive authoritative communicative approach was preferred by teachers when interacting with LPK.

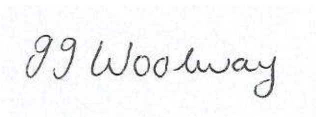
It was during PLC meetings that teachers reflected on their shared experiences. Teachers became aware of the prevalence of IRE interactions, the low order questions they asked, and developed activities to challenge possible alternative conceptions learners may have. Teachers started asking higher order questions. Interactions with learners included more IRPRE interactions, where the teacher would initiate an interaction asking a question (I), a learner world respond (R), the teacher would then either 'probe' the same learner or ask a classmate in a 'toss -back' move to explain their meaning. However, when learners went off task, teachers opted to either shut down the interaction or revert to an IRE pattern of interaction. More instances of teachers including an interactive dialogic communicative approach occurred.

The study confirms the value of sustained school-based support for teacher uptake of interventions. Effective professional learning occurs when the intervention considers the context of the teachers and learners, what the teacher knows and that teachers are provided a safe space where they can discuss challenges and solve problems. Participation in PLC meetings was a factor that influenced the way teachers interacted with LPK. The role of the leader in the PLC became evident, as they created a safe space for teachers to participate in discussions. Results showed as teachers attended more meetings, so their participation and the level of their reflection increased. The importance of identifying teachers to lead PLCs that could use an action research design to solve context-specific problems is highlighted.
Key Words:
Learner prior knowledge, patterns of interaction, professional learning community, reflection

Declaration

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

Signed:



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Dedication

I dedicate my thesis to my husband Ian and children Kate and Luke, whose continued support and encouragement throughout my PhD journey was unwavering.

I am so blessed.

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Presentations and Publication Emanating from this Research.

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Woolway, J., Msimanga A., & Lelliott, A. (2018). The influence of continuous collaborative reflection sessions on how Grade 8 Natural Sciences teachers reflect on working with learner prior knowledge. Short paper presented at the 26th Conference of the Southern African Association for Research in Mathematics, Science and Technology Education, University of Botswana, Gaborone, Botswana.

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List of Abbreviations and Acronyms

CAPS	Curriculum and Policy Statement
C2005	Curriculum 2005
EoEC	Effects of and electric current
GDE	Gauteng Department of Education
IRE	Initiate, respond, evaluate.
IRPRE	Initiate, respond, prompt, evaluate.
LoLT	Language of Learning and Teaching
LPK	Learner prior knowledge
NS	Natural Sciences
OBE	Outcomes-based education
PD	Professional development
PLC	Professional learning community
RNCS	Revised National Curriculum Statement
ZPD	Zone of proximal development

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Chapter 1 Introduction

1.1 Introduction

As young children, we explore the world we live in with much excitement and eagerness. Asking questions, investigating, playing, and touching. The world we live in is a magical place full of curious, strange, and wonderful people, places, animals, plants, and other things. When we reach age 5 or 6, we are sent to school to learn and understand this fascinating world. Moving through the years of schooling, the world we live in becomes irrelevant to our learning. In the classroom, focus shifts to completion of curricula, with content often far removed from what we have experienced outside the classroom.

Even though one of the aims of the newly implemented Curriculum and Assessment Policy (CAPS) is to '*ensure that children acquire and apply knowledge and skills in ways that are meaningful to their own lives'* (Department of Basic Education, 2011b, p. 4*)*, emphasis in the classroom is teaching the prescribed content to prepare learners to complete assessments. Little time is spent, exploring the knowledge children bring with them to class and somehow link this to new concepts to be taught (Mudadigwa & Msimanga, 2019). Yet for learners to make meaning of new concepts they must be given opportunities to make their prior knowledge known (Scott, Mortimer, & Aguiar, 2006). Through well-planned lessons, teachers are then able to mediate the learning of new concepts into learners' existing knowledge. In so doing it is hoped that the learning of new concepts, allows learners to make meaning of the world we live in.

In this chapter, the introduction to my thesis, I start by explaining the importance of exploring learner prior knowledge (LPK), a prerequisite to meaningful learning from a social constructivist perspective. I continue by stating some of the reasons why teachers both in South Africa and worldwide struggle to do this. I continue the chapter by identifying the problem and stating the purpose of my study. For the reader to understand why this research is important to me, I continue by discussing my context, being upfront about my positionality as a teacher and researcher. I go on to state my research question and sub-questions. Finally, I provide the reader with a broad overview of how I have structured my thesis.

1.2 Working with Learner Prior Knowledge in classrooms

From a sociocultural perspective, for learning to be meaningful, the teacher needs to create opportunities to mediate learning using the tools of language, by working with a group of learners or having learners work in groups. Talking is essential for learning to take place. Vygotsky (1978) stresses for learning to occur there needs to be a blending of what learners already know with the new concepts. The role of the teacher is to introduce new concepts and support learners as they move from what they can do on their own to that which requires assistance. Understanding of new concepts occurs once learners can make meaning individually.

Exploring LPK is not as easy as merely listening to various diverse learner contributions. Some of the LPK that is made explicit may agree with what needs to be taught, when this happens the learning of new concepts is ‘easy’ (Chi, 2008). In other instances learner understandings may conflict with currently accepted science concepts, or the teacher may discover that what they thought the learners should know is ‘missing’ or ‘incomplete’ (Chi, 2008). Sometimes learners’ responses may be unique and novel making the teacher feel unprepared and unsure how to respond (Ball & Bass, 2000). Further, some teachers find dealing with all learner contributions time-consuming, leaving little time to teach new concepts (Scott et al., 2006). In their studies, both Stears, Malcolm, and Kowlas (2003) and Mhlolo (2012) reported that when teachers asked learners about their prior knowledge, learner contributions were ignored, as the teachers were focused on completing the lesson they had planned. When teachers do provide opportunities to work with LPK, they tend to focus on knowledge gained from previous lessons in earlier grades (Lin, 2015) paying little attention to other sources of knowledge for example knowledge gained from everyday experiences or informal learning.

Tension is thus created: for meaningful learning of new concepts, the teacher needs to create opportunities for learners to make what they know explicit. If the teacher has not planned for what is uncovered, s/he now needs to decide how to work with knowledge, which may place the teacher in a vulnerable position, not knowing how to respond, or the teacher may not want to interact with the knowledge as it will take the lesson off its predetermined path.

In South Africa, recent education reform policies have sought to improve teaching and learning, emphasizing a move away from traditional authoritative lessons to ones where learners are active participants, and where the teacher explores what the learner knows.

1.3 Background

Since becoming a democracy, the South African government has strived to improve the quality of education in the country. Curriculum 2005 was implemented in 1998 to address the inequalities of apartheid (Department of Basic Education, 2011b). The post-apartheid education curriculum that was introduced was outcomes-based and had learner centered teaching at its core (Department of Education, 2002). Outcomes-based education (OBE) was seen as a vehicle for achieving the economic, social, and political goals of the newly elected democratic government (Chisholm & Leyendecker, 2008).

It was hoped with OBE, learners would achieve the following critical outcomes: (Department of Education, 2002) p.1

- Critical and creative thinking.
- Working together as a team.
- Managing themselves and their activities effectively and responsibly.
- Collecting, analyzing, and critically evaluating information.
- Communicating using visual symbolic and/or language skills.
- Show responsibility to the health of others and the environment.

However, problems with the implementation of OBE led to many frustrations both by the teachers and learners. The first version of OBE Curriculum 2005, (C2005) was revised in 2000 and renamed the Revised National Curriculum Statement Grades R-9 (RNCS), and the National Curriculum Statement Grades 10-12 (NCS). The RNCS was introduced in high schools in 2006. The RNCS was still based on a learner centered, activity-based pedagogy (Department of Education, 2002). The critical outcomes listed above were retained. However, the new curriculum saw specific skills learners needed to acquire at a particular level being stated. Textbooks were re-introduced (Nykiel-Herbert, 2004).

A task team was appointed to investigate the implementation of the RNCS, as learner achievements remained low. The investigation reported that teachers were confused, overloaded, stressed, and demotivated. As a consequence learners were underperforming (Department of Basic Education, 2011b). In its fifteenth year as a democracy, the South African government chose to revise its education policy once more. In 2009 Minister of Basic Education, Angie Motshekga announced that OBE was dead and that findings from the review committee were being addressed (Motshekga, 2009). This led the Education Department to develop The Curriculum and Assessment Policy Statement (CAPS) that was implemented in all grades in 2014 (Department of Basic Education, 2011a) and is the current South African Education Policy. The CAPS policy delineated each subject into topics, stating when each needs to be taught. The number of assessment tasks required per term is also stated. Textbooks are issued to all learners from Grade 4 to Grade 12 ensuring consistency in coverage, appropriate pacing, and better quality in terms of instruction and content (Department of Basic Education, 2011b). The same critical outcomes for C2005 and the RNCS are stated as the aims in CAPS. (Department of Basic Education, 2011b, p.5). Specific aims for each subject are clearly stated. In the Natural Sciences (NS) CAPS document (Department of Basic Education, 2011b), the second specific aim states that learners should be allowed to ask questions, discuss and relate prior knowledge with the new work. A year before CAPS was implemented, teachers attended 3- or 4-day training course during the school holidays, where they were informed of the requirements of being CAPS compliant.

Even with changes in the education policy, learner understanding of science concepts remains low. Results from grade 9 South African learners who wrote the TIMMS (2015) are poor (Zuze, Reddy, Visser, Winnaar, & Govender, 2017). It is important that learner understanding of concepts is sound in these earlier high school years, as it is in these years that the foundations for higher grades are laid. The poor Grade 9 results may help to explain why performance in both the Physical Sciences and Life Sciences Grade 12 National Senior Certificate school exit exams are low. Only 49% of Life Sciences learners and 52% of Physical Sciences learners achieved results higher than 40% (Education, 2020).

I have been teaching learners in a former model C[1] suburban high school for many years. My experience and observations of learners in the NS classroom are that their performance and understanding of concepts in NS is poor. They struggle to make meaning of school science. It is as though they have isolated school science in its own cognitive compartment and there it remains. They are shy to contribute to lessons, leaving a few individuals to do all the talking, while many hitchhike their way through lessons. Very few learners can explain or interpret what is meant in a given problem. My research is concerned with improving teaching in Grade 8 NS classes, by focusing on how teachers can explore LPK in a meaningful way, to link what

[1] A 'model C' school in South Africa is one which was attended only by white learners when South Africa was governed by Apartheid Policies. These schools are government schools. Currently, they are multi-racial. Model C schools are administrated and largely funded by a governing body of parents and alumni.

learners know, to new concepts being taught. In so doing it is hoped that learners will make sense of new concepts being taught and relate this new knowledge to the world we live in.

1.4 Researcher Positionality

At the time of writing my thesis, I have been teaching NS (Grades 8 and 9) and Life Sciences (Grades 10,11, and 12) for some 30 years. As a young girl, this is what I wanted to do, 'when I grow up': become a teacher. My father was thrilled at the idea and repeatedly said to me: 'Remember you need to educate, not teach, there is a difference'. Make sure that what you do in your class, allows your children to make sense of what they are learning. I agreed with my dad. Having my learners understand, and deeply make sense of the world they live in, is what is important to me.

My own experience of school was one of an education system that was Christian based and focused on results in high stakes examinations. Making sure you were able to answer the questions in the year-end examinations, was the reason you were at school. Incorrect answers were an indication of a lack of preparation. What mattered, was getting the answer right, memo perfect. Having achieved the necessary scores in Matric, I proceeded on to university, where I completed a Bachelor of Science degree, and then a BSc Honours, in Botany. I loved learning about the world we live in. This is the world I wanted to educate my learners about. I went on to complete a Higher Diploma in Education, providing me with the qualification to 'become a teacher'. Throughout the course, I was frustrated by the top-down approach that was used in telling me how I had to teach. I did what I had to, to get the qualification, to become a teacher.

I started teaching at the high school where I am still employed in 1991. The school is situated in a suburban area and when I started teaching was attended by only white children. The school is similar to the one I had attended as a learner. When I started teaching, South Africa was in turmoil. Nelson Mandela had been released the year before and the end of the apartheid system was imminent. With a change in government, so came changes in the Education system: 'OBE', full of acronyms and new ways of teaching. The focus had shifted from a content-driven curriculum to one which was open to much interpretation, with an emphasis on skills and values. Schools were now inclusive institutions, where learners from diverse racial, cultural, and religious backgrounds came together to learn. These were exciting times.

Several curriculum changes followed, each hoping to improve learner understanding and learner performance. I was excited about the changes, as including both skills and values into the curriculum created space for me to teach more than content. However, being a high school, performance in the Grade 12 exit examinations remained important.

Annually the release of the matric results is given much media coverage. It would seem the success of educating our children, lies in the interpretation of these results. For many years now, the first meetings in the school year, held by the District office, attended by teachers, usually starts with an unpacking of the district matric results. Schools are applauded, named and shamed, for all in the meeting to see. Following the finger-wagging, schools are clustered into predetermined professional learning communities (PLCs). Little guidance is given as to the purpose of the PLC, other than it is hoped through attendance at meetings matric results will improve. The same teachers whose schools have just been pitted against each other are now expected to work collaboratively, assisting each other to improve matric results. And so, year in and year out, the matric results are released, analyzed, and a top-down solution thrust upon teachers to implement. Yet, none of the experts suggesting solutions have asked teachers 'how could we improve learner understanding of concepts?'.

Being frustrated by the solutions experts were telling me to implement, and what I felt was classroom reality was what motivated me to conduct a small piece of research, where teachers were provided with a space to explore ways to improve the meaning learners make in the science class.

1.5 Purpose of my study

The South African government has attempted through various curriculum changes to improve teaching and learning by introducing policies that encourage learners to be active participants in their learning. Professional development (PD) programmes used to introduce teachers to new ways of teaching, involved a top-down approach, where teachers are told what to do. Implementation of the various curricula has fallen short of achieving the desired results. Some teachers have reverted to various forms of authoritative teaching approaches, with little active participation by learners (Stoffels, 2008), whilst others have left learners to be 'active participants' by working in groups with no real gain in new knowledge (Nykiel-Herbert, 2004).

Whilst much education research reports on the improvement of learner understanding of new concepts when learners are active participants, making their LPK known, teachers, struggle to provide opportunities for learners to make what they know explicit. Forcing teachers to attend once-off PD programmes where teachers are told what to do, without taking the context of the teacher or learners into account usually results in poor implementation (Cordingley, Higgins, Greany, & Buckler, 2015). Successful PD programmes are those that are sensitive to the teachers' context and experience, and where teachers are allowed to work together in a safe and trusted environment, such as a PLC (Durksen, Klassen, & Daniels, 2017).

The purpose of my research is to develop lessons that include exploring what learners already know about a topic, as a starting point for the teaching of new concepts. In so doing it was hoped that learners become active participants in their learning and make meaning of new science concepts. My research is underpinned by the work of Vygotsky that states knowledge is socially constructed. For this reason, not only is it important to include opportunities for learners to use the tools of language to make what they know explicit, so too participant teachers need to be provided a space where they are able to work together creating opportunities to find out what learners already know.

When learner contributions focused on LPK have been incorporated into lessons, learner performance increases (Stears et al., 2003). However, some teachers struggle to elicit and incorporate learner prior knowledge into lessons. Teachers are either rushed to complete the curriculum (Scott et al., 2006) or teachers are unable to work with the learners' contribution as they may be new and the teacher is unable to incorporate it into the work being taught (Ball & Bass, 2000). Being aware of these reported difficulties teachers experience when exploring LPK, I did not want my research to come in with a ready-made solution, rather I wanted to work with teachers in a PLC where through much planning and reflection on lessons, we developed, reflected, and revised activities to explore LPK in a meaningful way.

The purpose of my research was to work with teachers to find ways to interact with LPK so that the learning of new concepts is not isolated from what learners already know. The research I am reporting on is concerned with firstly reporting on how Grade 8 NS teachers in their baseline practices interact with LPK. I then consider how participant teachers interacted with LPK, having worked collaboratively in a PLC, developing activities and lesson plans focused on exploring what learners know. I show how teacher interactions with learners in the second year of the study changed, compared to the first year, as teachers had reflected and reworked activities from their experiences in the first year. Working collaboratively in PLC provided opportunities for teachers to reflect on what had happened in the classroom and to rework activities for future lessons. I also report on how teachers' reflective practice changed over the two years of the study.

1.6 Aim of research and research questions

In this section, I articulate the aim of my research and research questions that guided my study. I also discuss how I went about answering each research question. My research aimed to work with grade 8 NS teachers, to provide opportunities for learners to make what they already know about the two topics explicit: effects of electric current (EoEC) and light. When planning activities teachers considered possible sources of knowledge, challenged alternative conceptions learners may have and how they (the teacher) would interact with learners.

The question that guided my research was: How do interactions concerned with exploring learner prior knowledge change, as teachers participate in a PLC focused on encouraging learners to make their knowledge explicit? I analyzed my data in terms of the following sub-questions:

1. In their baseline teaching practices, how do teachers interact with LPK?
2. Why do teachers interact with LPK in the ways that they do?
3. What influence does attendance at successive PLC meetings focused on reflecting how teachers engage with LPK, have on teacher participation and their level of reflection?

I continue by unpacking each of the research sub-questions further.

1.6.1 Research Sub-question 1: In their baseline teaching practices, how do teachers interact with LPK?

To answer my first research sub-question, teachers selected a lesson that would be their 'baseline lesson'. I observed and recorded the lesson. Data were analysed to identify when in their lesson teachers explored LPK, as well as the source of the LPK according to the categories given by Lin (2015): formal instruction, informal learning, intuition, language, cultural and religious beliefs . To unpack the preferred patterns of interactions teachers used when exploring LPK, I coded all interactions involving LPK, as either IRE (initiate, respond, evaluate) or IRPRE (initiate, respond, prompt, respond, evaluate). Whilst IRE interaction allows for interaction between the teacher and learner, the communicative approach used is considered interactive authoritative, in that the teacher is seeking a correct answer to the question and only one voice is heard (Mortimer & Scott, 2003). This contrasts to an IRPRE interaction, where the teacher opts to explore learner meaning further by either prompting the same learner to explain their meaning further or asking a classmate their views or further explanation in a 'toss back' move. When teachers use IRPRE interactions a space is created for more learner voices to be heard and the communicative approach used moves to being interactive dialogic (Mortimer & Scott, 2003).

Having explored how teachers use LPK to inform their lessons, teachers developed activities within the content areas EoEC and light that provided opportunities for learners to make what they already know explicit, as well as challenge common alternative conceptions learners may have.

1.6.2 Research Sub-question 2: Why do teachers interact with LPK in the ways that they do?

When answering this second research sub-question I first considered how the patterns of interaction (IRE and IRPRE) changed over the two years of data collection. I coded both learner responses (R) and teacher moves (P and E) in teacher-learner interactions that included exploring LPK. By unpacking the pattern of interactions that occurred over the time data were collected, factors became that influenced the way teachers chose to work with LPK emerged. If it was not for the PLC meetings that provided teachers with an opportunity to reflect on what had happened in lessons and plan for future lessons, it is likely that the changes in the patterns of interaction that occurred might not have happened.

1.6.3 Research Sub-question 3: What influence does attendance at successive PLC meetings focused on reflecting how teachers engage with LPK, have on teacher participation and their level of reflection?

As the project continued it became evident that attendance at PLC meetings was significant in changing the ways teachers interacted with LPK. It is by reflecting on their practice that teachers become better skilled (Zeichner & Liston, 2013). The purpose of this research sub-question was to track how teacher participation and reflective practice changed with continued attendance at meetings. This was of interest as findings would highlight the value of teachers participating in PLCs to find solutions to their context-specific problems.

1.7 How I answered my research questions

My research is a qualitative study located in the interpretivist research paradigm. As I was interested in finding out how teachers planned, taught, and reflected on interacting with LPK, I used an action research design. Data were collected over two years with five cycles occurring.

Cycles were defined by the content that was taught. In year 1, three cycles were completed: Cycle 1 Baseline practices, Cycle 2: EoEC, and Cycle 3: Light. In year 2 the following cycles occurred: Cycle 4: EoEC and Cycle 5: Light. Four grade 8 NS teachers were participants: Adele, Kate, Luke, and me. All teachers taught in the same suburban high school south of Johannesburg.

1.7.1 Data collection methods and forms of data

Data for this project were collected in many different forms: first teachers were interviewed individually using a semi-structured format. Each teacher was interviewed three times during the project: at the start of the project, end of year one, and the end of year 2. Excerpts of transcripts from these interviews were used to explain why teachers did what was observed in the classroom, in so doing providing the reader with a rich description of what happened.

All lessons forming part of the project were video and audio recorded. I sat at the back of the class observing the lesson and making field notes. The field notes included details of the context and my thoughts on what I was observing. Teachers were asked to reflect on their lessons, the 'reflections' were used to provide insights into teacher thoughts on their lessons.

All recorded lessons were transcribed, and the analysis focused on how teachers interacted with LPK.

Finally, PLC meetings were audio recorded. Having transcribed the audio recordings from PLC meetings teachers' participation and reflective practice were analyzed.

1.7.2 Data analysis and interpretation of results

Aspects of Mortimer and Scott's (2003) framework for analyzing meaning making interactions in science classrooms was useful in helping me make sense of my data. Particularly those parts that considered the patterns of interactions taking place between the teacher and learner, namely IRE vs IRPRE. Having identified the type of interaction that occurred I unpacked learner responses ('R') and teacher moves ('E' and 'P') using the coding scheme from (Pimentel & Mc Neill, 2013). Learner responses were coded as having been one of the following: no thought, single words or phrases, complete thoughts, or complete thoughts with reasoning. Responses that are single words, do not provide much insight into learner understanding. Encouraging learners to explain what they mean, often required teachers to 'prompt' a learner further, rather than evaluate a response. In other instances, teachers would use a 'toss back' move', to have a peer elaborate on a response. The moves teachers used in response to a learner utterance were coded as: evaluate, probe, toss back, cut off, ignore or elaborate.

To help me analyze teachers' reflective practice, I used a hybrid of Zeichner and Liston (2013) and O'Sullivan (2002) to code the level at which teachers reflected in PLC meetings. Teachers who were able to give reasons to explain why events happened were coded as 'craftsperson', this contrasts to a teacher who when they reflect can identify problems. The latter type of reflection was coded 'basic technician'. By coding the level at which teachers reflecting in PLC meetings, across the cycles, I was able to track changes in both participation and the level at which teachers reflect as the study proceeded.

1.8 Significance of the study

My study aimed to unpack how the interactions between teachers and learners changed as teachers worked towards developing lessons, that created opportunities for learners to make what they already know explicit. Not only does much education research report on the importance of using this knowledge as the starting point for the meaningful learning of new concepts (Ausubel, 1968; Driver, Asoko, Leach, Mortimer, & Scott, 1994), so too does the current CAPS curriculum (Department of Basic Education, 2011b). By concentrating on two topics in the Grade 8 NS curriculum I was able to explore some of the factors that influenced teachers to make the decisions they did regarding how they interacted with LPK. Making these known could help NS teachers plan their lessons so that they become aware of how to explore the knowledge their learners bring to class, making the learning of new concepts meaningful.

Secondly, whilst many PD programmes are offered to teachers providing various interventions or strategies to implement in the hope of improving learner understanding, I wanted teachers in my study to be involved in finding better ways to interact with LPK. For this reason, teachers in my study formed a PLC with a focus on reflecting on and reworking activities. My study showed how teachers' participation and reflective practice changed as they attended more PLC meetings. This finding is significant, as if teachers who share a common problem form a PLC, it is possible that with continued back and forth discussion, they will be able to come up with their own solution to the problem. The significance of creating a safe space for teachers to collaborate is highlighted.

Whilst it is hoped that findings from my study will influence how teachers interact with LPK, in other schools, particularly in South Africa, my study is limited in that it is reporting on findings of four teachers, teaching at the same suburban high school. One would need to be cautious in transferring these findings to schools whose contexts are different, for example, rural schools.

1.9 Thesis Overview

In this section, I provide the reader with a brief overview of how I have written up each chapter of my thesis.

1.9.1 Chapter 1: Introduction

In the first chapter, I have argued that the reality in many science classrooms is on the teaching of new concepts, even though much research shows for learners to make sense of new knowledge, it is necessary for teachers to link this knowledge to what learners already know. Little time in lessons is given for learners to make explicit what they already understand. Whilst curriculum reforms in South Africa have strived to improve learning, evidence from results in matric exams and international tests, suggest that understanding of science concepts remains low. Perhaps one of the reasons for poor understanding of concepts is that teachers do not spend much time interacting with LPK. I am upfront about my motivation for conducting this research in that I am a teacher who is interested in working with colleagues to explore how better to interact with LPK so that new concepts being taught are not isolated from what the learners already know. The chapter also highlights, the importance of teachers working collaboratively in a PLC. I state the research questions this project sought to answer. I provide the reader with an outline of the research paradigm that guided what I did and gave a summary of the research design used, the forms of data collected, and how these were analysed. I concluded the chapter by stating why this study is significant.

1.9.2 Chapter 2: Literature Review

I start my literature review by explaining Vygotsky's sociocultural theory, as this is the theoretical lens through which I look at my data. The following aspects of this theory were useful in my study and I describe them: mediating knowledge construction using the tools of language, the zone of proximal development, the blending of 'spontaneous concepts' with 'science concepts'. My literature review continues by reporting on findings from research that are concerned with exploring LPK and the significance of teachers working within a PLC to change their practice. I unpack research concerned with LPK, including what it includes, where it comes from, the role of LPK in making meaning of new concepts, and discuss some of the challenges teachers may encounter when they interact with LPK.

I continue my literature review by arguing for PLCs as a form of PD that provides support to teachers as they share common experiences and reflect on what happened in the classroom. Reflecting on how they (the teachers) interacted with LPK, was essential, as it is only when teachers reflect on their practice that they become better and more skilled teachers as they change that which is not successful. I end the chapter by exploring literature on teacher reflective practice.

1.9.3 Chapter 3: Methodology

In chapter 3 I explain why I used a *practical action research*, research design to collect data in my qualitative study, which is located within an interpretivist paradigm. I provide detail about the context of the school, and the four participant teachers. At the time of collecting data, I was the Head of Department, and I describe aspects related to ethics as I was aware of my position and wanted to ensure as far as possible that I did not abuse my position of power. Details regarding the methods of data collection as well as the analytical frameworks used to analyse both teacher-learner interactions and the levels of teacher reflection are described.

1.9.4 Chapter 4: Baseline Practices

Chapter 4 is the first chapter where I present findings on how teachers interact with LPK. Data were collected from baseline lessons and was used to answer my first research sub-question: in their baseline practice, how do teachers interact with LPK? I report on when teachers explored LPK and identify the sources of LPK teachers interacted with during their lessons. I code the interactions involving LPK, that occurred during the lesson as being either IRE or IRPRE. I then unpack both learner responses ('R') and teacher moves ('E' and 'P') by using the same coding as Pimentel and Mc Neill (2013).

1.9.5 Chapter 5: Changing the way we work with LPK.

Chapter 5 answers my second research question: Why do teachers interact with LPK in the ways that they do? Teacher interactions with LPK were identified in lessons that form part of cycles 2,3,4 and 5. Like the baseline data, interactions were coded as being IRE or IRPRE. Learner response and teacher moves were also coded. This allowed me to make comparisons with how teachers interacted with LPK in the same content area from one year to the next. Cycles 2 and 4 were focused on the same content (EoEC) in year 1 and 2 respectively, whereas cycles 3 and 5 focused on the topic light in year 1 and 2 respectively.

Having analysed changes in the patterns of interaction over the cycles, I used information gained from transcripts of PLC meetings as well as interviews to gain deeper insights into why teachers opted to explore LPK the way that they did. In so doing, some of the factors that facilitated or impeded teachers exploring LPK emerged.

1.9.6 Chapter 6: Teachers' Reflective Practice

Chapter 6 considers changes in teachers' reflective practice with continued attendance at PLC meetings, and allowed me to answer my third research sub-question: what influence does attendance at successive PLC meetings focussed on reflecting how teachers engage with LPK, have on teacher participation and their level of reflection? The focus of the PLC meetings was for teachers to reflect on how they interacted with LPK and rework lessons to improve these interactions, allowing learners to link what they already know to new concepts being taught.

I was able to track teacher participation and the level at which teachers reflected through the two years they attended PLC meetings. It was by working collaboratively in a PLC that teachers were able to consider aspects of their lesson that needed improving and then go about revising how they interacted with LPK.

1.9.7 Chapter 7: Concluding remarks

In the final chapter of my thesis, I describe key findings that have emerged from my study. I discuss the possible implications of these findings in terms of teacher development, education policy, and research. I also acknowledge the limitations of my study.

1.10 Chapter Summary

I have described the tension that exists between what research and policy state as the starting point of meaning-making in classrooms, uncovering what learners already know and the reality of teachers spending little time exploring this knowledge. I provided some background on my context and outlined the purpose of my study as working with my colleagues in a PLC, to develop activities and planning lessons provided opportunities for learners to make their prior knowledge explicit. I outlined my research questions and briefly described the data collection methods and how the data were analyzed. I provide a short account of the significance of my study. I conclude the chapter by providing the reader with an outline of the chapter breakdown of my thesis. In chapter 2, my literature review, I unpack various issues raised in education research both local and international that are relevant to my study.

Chapter 2 Literature Review

2.1 Introduction

Having motivated and set the scene for my study in Chapter 1, in this Chapter I review literature that grounds my project and gives insight into published work that speaks to my research questions. I have used Vygotsky's sociocultural theory as a lens to guide my research.

I start my literature review by unpacking aspects of Vygotsky's sociocultural theory relevant to my project: progressing learning from the interpsychological plane to the intrapsychological plane through internalization as well as working within the zone of proximal development (ZPD). Moving learners (and teachers) from what they can do on their own, to what they can achieve when assisted. I then provide a conceptual framework for my study, showing how various concepts are related and the influence various factors have on these concepts.

I go on to discuss literature describing learner prior knowledge (LPK): what it includes, where it comes from and the part LPK plays in meaningful learning. The review moves to focus on various ways teachers can work with LPK. The literature I have reviewed concerning LPK, is the background to my first two research sub-questions. My first research sub-question asks: in their baseline teaching practices, how do teachers interact with LPK? The second research sub-question is concerned with answering the question: Why do teachers interact with LPK in the ways that they do?

The latter part of this chapter looks at literature published on improving teachers' practice, with a focus on the role reflection on practices, particularly with the way teachers explore LPK. Instances have been reported that show teachers sometimes struggle to reflect. I consider the role of professional development (PD) programmes in supporting teachers to reflect. I conclude the literature review by exploring the role of professional learning communities (PLCs) as a form of PD, to achieve this end. PLCs have shown much promise in terms of creating safe spaces for teachers to reflect.

2.2 Theoretical Framework

My research is grounded in Vygotsky's sociocultural theory which describes learning as mediated process, using the cultural tools of language to allow concept formation. When facts are simply transferred from teacher to learner, often ineffective learning results. In the words of Vygotsky:

> '*Direct teaching of concepts is impossible and fruitless. A teacher who tries to do this usually accomplishes nothing but empty verbalism, a parrotlike repetition of words by the child, simulating a knowledge of the corresponding concepts, but actually covering up a vacuum.'*
>
> (Vygotsky & Kozulin, 1986, p. 150)

Vygotsky (1978) maintains that learning occurs on a social plane. The social plane may be a teacher working with a group of learners, or a group of learners working together. As ideas are expressed and explored each person may reflect on and make sense on what is being communicated, in the interpsychological plane. The tools used during the interaction may be words, gestures or images (Vygotsky, 1978). As such Vygotsky regards learning as appearing on two levels: first it occurs between individuals as an 'interpsychological process' and then it occurs within the individual as an 'intrapsychological process'. Thus, there is a move from the interpsychological to the intrapsychological where the tools of communication allow the learner to think individually. Vygotsky (1978) refers to this process of individual meaning making as internalization. The process of internalization is gradual: initially the teacher or more capable peer will guide the learner as they try and make sense of a new concept. There would be a move from a more authoritative approach, to providing the learner with feedback as they try to make sense of a new concept. As the learner gains more confidence and makes meaning of the new concept so the process of internalization occurs. My study looked at providing learners with opportunities to make their prior knowledge explicit by working in small groups and whole class discussions. It was using the tools of communication: both speech and writing where opportunities were created that allowed learners to move from the interpsychological plane to the intrapsychological plane.

According to the sociocultural perspective on learning, talking is essential for learning to take place. For instance, when a teacher introduces learners to a new word, learners may understand the teacher's definition of the word. However, including the word into their own vocabulary may seem foreign to learners. Until the learner uses the word easily and in various contexts no real learning has taken place. Vygotsky (1978) asserts that the teacher's role is to support learners as they gradually gain the expertise and confidence in working with new concepts. Throughout my study, activities were designed to provide opportunities for learners to communicate with their peers in small groups. Small group discussions provided chances for learners to explain their meaning. As it is not possible for a teacher to hear all small group discussions at the same time, whole class discussions become useful. Whole class discussions allow teachers to become aware of how some learners make meaning. For instance, when speaking about the concept ‘density’, a teacher may refer to ‘volume’, meaning a measurement of a liquid. Yet when the teacher probes a learner, s/he may find the learner interprets ‘volume’, as the degree of loudness of sound. The role of the teacher would be to mediate learning, moving learners from that which they can do on their own to that which may be achieved with help using the tools of communication. This leads me to discuss two notions of Vygotsky’s sociocultural theory of learning: the role of mediation, followed by a short explanation on moving learners through their zone of proximal development.

2.2.1 Mediation

According to Vygotsky higher mental processes are mediated by tools such as language, signs and symbols. Karpov and Haywood (1998) distinguish between two types of mediation: metacognition mediation and cognitive mediation. Metacognition mediation is concerned with explaining self-regulation in children. It is dependent on interpersonal communication: where children interact either with an adult or more mature peer using semiotic tools. The development of self-regulation goes through the following stages: first, using speech. For instance, a mother may say to a child: “don’t touch that, it’s hot”. Second, the child either regulates his/her own behaviour using egocentric speech, speaking out loud to themselves: “don’t touch, it is hot” or the child regulates someone else’s behaviour using speech. Finally, the child regulates his/her own behaviour using internal speech. This research project is not concerned with metacognition mediation, but rather cognitive mediation.

Cognitive mediation is concerned with acquiring the cognitive tools needed to solve subject specific problems, as taught in a school curriculum. Cognitive mediation starts when a child begins school and is taught what Vygotsky refers to as ‘science concepts’(Vygotsky, 1978). Science concepts are those generalizations that are accepted by science and taught to children in an organized curriculum. Yet children go to school with their own ‘spontaneous concepts’. Spontaneous concepts refer to the meanings a child has made, based on the internalization of concepts that have arisen from their personal experiences. The development of spontaneous concepts is often unsystematic and based on observations. In some instances, the internalized spontaneous concept may be incorrect. For instance, a child observing small objects e.g., a needle and coin sinking in water, may conclude that if an object is small it will sink.

The new ‘science concepts’ being taught at school therefore interact with the child’s ‘spontaneous concepts.’ Vygotsky (1978) stresses for learning to occur, opportunities need to be created where there is a blending of ‘spontaneous concepts’ with ‘science concepts. Cognitive mediation of concepts could be used to achieve this end. Karpov and Haywood (1998) and Driver et al. (1994) have varied ideas of how mediation should occur. Karpov and Haywood (1998) suggest that for cognitive mediation to occur, opportunities are created where learners are taught methods of scientific analysis allowing them to model and identify characteristics of objects and events. Once learners have internalized the methods, these then allow the learners to solve similar problems in different contexts, particularly when opportunities are created around collaborative activities. Driver et al. (1994) state that the role of the mediator is twofold: first, to introduce new concepts and provide support and guidance as learners make sense of the concept. Second, to reflect on how learners are interpreting activities and concepts, to inform future lessons. I have taken the role of the mediator from the work of Driver et al. (1994).

The mediator would be considered the expert, guiding novices (usually learners) in how they think. Before moving on to consider the ZPD I will briefly consider novice-expert shifts. In their study looking at the gains in astronomy knowledge of participants from novice (pre-school learners) to expert (astronomy professors) Bryce and Blown (2012) showed that there is a gradual acquisition of knowledge from childhood to adulthood. There is a shift from novice to expert. The knowledge gains were attributed to passionate teachers (experts) who created nurturing learning environments. This contrasts to findings from Jacoby and Gonzales (1991) study, where the authors analysed science talk between a physics professor, post-doctoral and doctoral students. Whilst many discussions showed the professor to be the expert, there were instances where the ‘novice’ was considered the ‘expert’. They concluded that shifts between being a novice and expert may occur as interactions proceed.

Teachers (experts) in my study explored ways to provide opportunities for learners (novices) to make their ‘spontaneous knowledge’ explicit and then move learners through their zone of proximal development (ZPD), as they interacted with the ‘science concepts’ detailed in the Grade 8 Natural Sciences (NS), Curriculum assessment and policy statement (CAPS) curriculum. I turn my discussion on my theoretical framework to focus on the ZPD.

2.2.2 Zone of Proximal Development

The ZPD is the difference between what a learner can achieve when working with assistance and without assistance. A role of the teacher is to support learners as they move through their ZPDs (Vygotsky, 1978).The support teachers offer may be achieved by monitoring learners' understandings and responding to those understandings. How the teacher supports learners as they move through their ZPD is crucial for meaningful learning to take place. Thus the teacher needs to be tapping into the learners' prior knowledge (spontaneous knowledge) and their potential level of unassisted performance (Mortimer & Scott, 2003). Meaningful learning requires both the teacher and learners to 'talk science', starting from what the learners know and guiding the learning as learners make sense of the new concepts. Teachers should strive to remain within the 'zone' of what learners are realistically capable of and that which is required by the curriculum, achievable by mediation. Once a learner can complete activities on his or her own, the learner would have moved through their ZPD.

In my study activities and discussions were planned with the purpose of exploring LPK, considering 'spontaneous concepts' learners have and using this to link to new concepts. Following lessons teachers reflected on learner responses, and reworked lessons to better move learners through their ZPD. Some researchers have transferred Vygotsky's ZPD from how children learn, to how adults (teachers) learn.

A recent study has used Vygotsky's sociocultural theory to explain how teachers assisted each other to move through their ZPD. Kuusisaari (2014) worked with in service Home Economics teachers, from Finland. Teachers in her study participated in group work, where the focus was on linking theory (constructivism) to practice. It was hoped that by working collaboratively teachers would move from what they could do on their own to that which they could not. There was no expert mediating the move through the ZPD, rather peers assisted each other in the groups, in what she termed symmetrical collaboration. Asymmetrical collaboration by contrast makes use of an expert, that mediates the move through the ZPD. Findings from her study showed that only one of the three groups were able to move through their ZPD. Kuusisaari questioned whether the two less successful groups may have benefited from asymmetrical collaboration, by having a facilitator encourage robust debate over suggestions made by group members. However, Kuusisaari (2014) acknowledged that the ultimate goal should be to have teachers collaborate without a facilitator as they are not always available.

In an earlier study, Jones, Rua, and Carter (1998), explored how elementary and middle school science teachers from the south eastern parts of USA, moved through their ZPD. Teachers were purposively paired, an experienced teacher with an inexperienced teacher. Their study showed gains in teacher content and pedagogic knowledge as the teachers worked within their ZPD. The conceptual growth was a product of many complex interactions using varied mediating agents. Opportunities for interaction were created through discussions, drawing of concept maps and journaling. Findings from their study showed instances of asymmetrical collaboration where experienced teachers assisted less experienced teachers to move through their ZPD. However, the same authors reported instances where the novice teacher supported learning of the experienced teacher. They attributed this to the varied understandings and prior experiences each teacher possesses as well as to the complexities of the science concepts being studied. The study highlighted the value of peers sharing experiences and knowledge in promoting conceptual growth in teacher development programmes.

More recently, Wilburn (2019) reported on some schools in poor South African communities using ‘expert’ teachers as a pedagogic resource. Findings from this study showed Grade 3 learners’ performance was higher where their Mathematics teachers made use of an ‘expert’ teacher, compared to teachers who ignored this resource. Expert teachers were identified as those teachers whose colleagues had acknowledged them as being a ‘good’ teacher; and/or teachers whose learners test scores were considered excellent and/or one’s who the principal had identified as being expert teachers, based on class visits.

In my study teachers worked collaboratively developing lessons and activities focussed on moving learners through their ZPD. Following collaborative planning sessions. teachers taught the content and met to reflect on what had unfolded in the classroom. One of the teachers took the lead during reflect and plan meetings, guiding the others on their reflections. In so doing the expert teacher was used as a pedagogic resource, as they assisted teachers with their reflective practice, moving teachers through their ZPD. This will be discussed further in the chapters that follow.

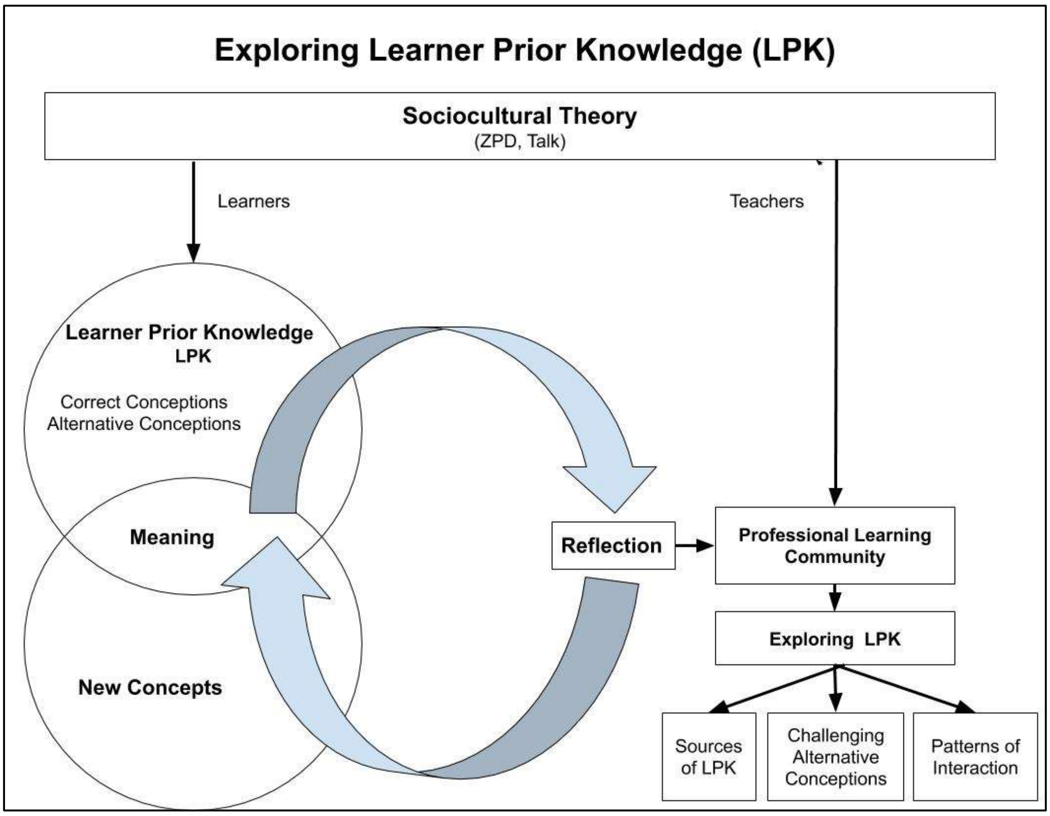
To illustrate how Vygotsky's theory of sociocultural learning guides my research the focus of my literature review turns to the conceptual framework of my study.

2.3 Conceptual Framework

The purpose of a conceptual framework is to explain both narratively and graphically relationships between key constructs, variables and factors that play a role in a research project (Robson & McCartan, 2016). I have developed my conceptual framework to map out and show how various theories and concepts link together to help answer my three research questions. My thesis has its theoretical foundation on Vygotsky's sociocultural theory. Aspects of Vygotsky's theory useful to my study are the role of language in mediating learning and the notion of the ZPD. (Figure 1). Both these aspects, talk and the ZPD, were relevant to the how learners were taught and how teachers reflected on their practice.

My study explores how teachers' interactions with learners' existing knowledge change as teachers participate in a PLC. When the teacher is able to link LPK with new concepts being taught it is likely that learners will make deep meaning of those concepts (Mortimer & Scott, 2003). As such teachers move learners through their ZPD, by establishing what they can do on their own and moving them to new understandings.

Figure 1 Conceptual Framework for my Study



Whilst it is hoped that the process of blending what learners already know with new concepts will be successful, this is not always the case. For this reason, teachers worked within a professional learning community (PLC) teachers to reflect on what had happened in their classes and then revise lessons to address concerns raised. The focus of PLC meetings was to reflect on how the teachers explored LPK. This included considering LPK gained from various, including common alternative conceptions learners bring to class and how to challenge these. Teachers also reflected on how they could improve the 'talk' in their class, by exploring the patterns of interactions that happened during a lesson. This included reflecting on the types of questions asked, learner responses, and teachers' replies to learner responses.

Working collaboratively within a PLC, teachers were provided with opportunities to improve their own reflective practice as they were assisted by more experienced teachers. Through participation in PLC meetings, teachers could move through their ZPD, with the assistance of a colleague.

Those concepts focused on the linking of new concepts with LPK, including 'sociocultural theory', 'sources of LPK', 'alternative conceptions' and the 'patterns of interaction' were used to answer my first two research sub-questions. In their baseline teaching practices, how do teachers interact with LPK? The second research sub-question: why do teachers interact with LPK, the way they do? Concepts that answer my third research sub-question, what influence does attendance at successive PLC meetings focused on reflecting how teachers engage with LPK, have on teacher participation and the level of reflection, include 'reflection', 'professional learning community' and 'sociocultural theory'.

I continue my literature review to first unpack the significance of LPK (see 2.4) as a starting point for meaningful learning. This is followed by an argument considering how to change what teachers do through professional development (see 2.5) and reflecting on what has happened (see 2.7).

2.4 Learner Prior Knowledge

Learners come to class with varied LPK because of their different experiences. Some of this knowledge may or may not agree with currently accepted science concepts. Before discussing where this knowledge comes from, why and how teachers should include LPK in their lessons, it is necessary to define what is meant by LPK. I take my definition of LPK from Bricker, Reeve, and Bell (2014) who stated that learner prior knowledge:

> *Encompasses culturally influenced and framed understandings, experiences, and practices (material, social and intellectual) that a learner utilizes during any given learning moment.*
>
> (Bricker et al., 2014, p. 1458)

LPK therefore refers to the collection and the linking of conceptions held by the learner when they enter the science classroom. Conceptions are internal representations learners have constructed from external representations of entities that have been presented by other people for example teachers, software designers or authors (Duit & Treagust, 2012). Representations refer to the way a person communicates ideas either internally by thinking about their ideas, or externally by presenting ideas either verbally or in the written form (words and or pictures), using one or more of these forms (Duit & Treagust, 2012).

The knowledge learners bring with them to class has a significant influence on the learning process (Driver, 1983). Scott, Mortimer, and Ametller (2011) maintain that it is the role of the teacher to facilitate learning by creating opportunities allowing learners to link what they already know to that which needs to be learnt. When such opportunities are provided it is likely that meaningful learning will occur. However, often teachers ignore or pay little attention to LPK (Mudadigwa & Msimanga, 2019). When teachers do include LPK in their teaching, they tend to focus on LPK coming from a single source, for example formal education (Lin, 2015).

Lin (2015) categorizes sources of LPK into the knowledge gained from the following: formal instruction, informal learning, everyday experiences, intuition, and language. I will briefly discuss each source of LPK category as described by Lin. I have added a sixth category, described by Bricker et al. (2014), knowledge learners have gained from their cultural and religious beliefs.

2.4.1 Sources of LPK

2.4.1.1 Formal Instruction

Some conceptions learners have about the world they live in, has been derived from science classrooms. Many teachers, particularly inexperienced teachers only consider this knowledge when working with LPK (Lin, 2015; Meyer, 2004). Whilst knowledge gained in previous classes may be correct it may be also be lacking and a source of alternative conceptions (Bar & Travis, 1991; Gomez-Zwiep, 2008). In her study Lin (2015) reported that well qualified experienced primary school teachers were unable to predict alternative conceptions learners may have and planned only for knowledge that should have been taught.

Conceptions learners have gained from formal instruction are dependent on the instruction they have received. Taber and Tan (2011) reported that some alternative conceptions learners have, may come from the instruction they received. In their study, they found the same alternative conceptions prevalent amongst the pre-service teachers. The researchers noted that the alternative conceptions were resilient to change. The pre-service teachers retained them, even after instruction explaining the widely accept science concepts. Where teachers have an alternative conception, it is likely that they will pass on the on the inaccurate knowledge (Taber, 2001).

2.4.1.2 Informal Learning

Learners make sense of the world around them through diverse informal learning sources. These sources include: websites, television programs, magazines, newspapers, social media and books (Taylor & Kowalski, 2010). In their study of first year psychology students, Taylor and Kowalski (2010) argued the greatest source of alternative conceptions amongst their participants was prime time news shows and newspapers. Whether this is true for learners in South African schools has not been reported.

2.4.1.3 Everyday Experiences

Learners live in a real world and come to experience it in everyday terms (Driver et al., 1994). For instance, most children have experienced the freezing and boiling water. Where their everyday way of knowing and the science way of knowing are consistent, the science knowledge is considered “straight forward” or “common sense”(Mortimer & Scott, 2003). However, where their everyday way of knowing and the science way of explaining the same phenomena differ, to the learner, it is usually the science way of knowing that is providing the alternative conception, and this may be why so many alternative conceptions are resilient to change and persist (Berger, 1967). For instance, one such alternative conception learners hold on to; is that matter can disappear. This is what they have observed when watching a log fire burn down (Driver et al., 1994). Careful consideration needs to be given to the everyday way learners experience science concepts, when planning lessons as failing to do so may result in learners developing or holding onto alternative conceptions (Georgiou & Sharma, 2012). When everyday experiences are included in lessons, learner engagement in the lesson increases and learners are able to link science knowledge with the everyday way of knowing (Stears et al., 2003).

2.4.1.4 Intuition

Learner intuition plays an important role in science learning (Lin, 2015). For example, based on their intuition learners, may believe that gas has no weight. Lin argued that learner understandings that are derived from intuition are not robust; they are readily replaced by scientific explanations of phenomena. However, this contrasts to the findings of Taber and Tan (2011), who noted that some intuitive alternative conceptions high school learners from Singapore hold onto in the topic ionization energy are difficult to challenge as they make sense to the learner and are as the authors state 'very stable'. They tend to form the 'hard core' conceptions for developing understanding in the topic. The learners in Lin's study were from a primary school in Taipei.

2.4.1.5 Language

Language (talking, listening, reading, and writing) is an integral part of science (Yore & Treagust, 2006). That the science way of talking about phenomena is rather different to the everyday way of explaining the same phenomena is well documented (Georgiou & Sharma, 2012; Lin, 2015; Mortimer & Scott, 2003). Yore and Treagust (2006) recognise a 3-language problem that exists for science learners in the various ways they experience English: everyday home language, the language of instruction and then science language. Some words used in everyday English language have numerous meanings and associations that hinder learning, for example: heat, work, insulation and energy (Georgiou & Sharma, 2012). Further, alternative conceptions often arise when the everyday way of speaking about scientific phenomena is different from the science way. For instance, a child may be asked to close the door to stop the cold coming in (home language). It is rather unlikely that the child will be asked to close the door, so as to not let the heat energy out of the house (science) (Lin, 2015).

This problem is compounded when learners are learning science in a language that is not their home language (Yore & Treagust, 2006). It is generally agreed that the language of learning and teaching (LoLT) is more than a medium of communication, it is the way learners construct an understanding of the practices and concepts within science (Rollnick, 2000). When learners are using a second language as language of science instruction these learners are doubly challenged since not only is it expected that these learners are proficient in the LOLT, but it is also expected of them to become proficient in 'science language', a task which many first language speaking learners struggle with themselves, as science terminology is different to the terminology used in everyday language (Rollnick, 2000).

2.4.1.6 Cultural and Religious Beliefs

Bricker et al. (2014) argue that LPK cannot be separated from the cultural milieu in which it is found. Much of what learners' think is embedded in the cultural norms and practices into which they are socialized. Their ethnographic study focused on two middle school learners from a low-income neighbourhood in the US and showed how learners draw on their rich and diverse cultural knowledge in their understanding and when making decisions related to personal health issues. Science classrooms tended to ignore this wealth of knowledge, opting rather to focus on teaching science concepts that were decontextualized. They recommend that teachers take time to elicit LPK and work with this knowledge, when presenting science concepts. In so doing, learners can see where the science way of knowing contradicts or supports what they believe to be true.

The persistence of traditional cultural beliefs was also reported by Ogunniyi (1987) in his study looking at the cosmological notions Nigerian learners and preservice teachers held onto. He concluded that once the preservice teachers had completed a nature of science course, they could accommodate both scientific and traditional conceptions of the universe, each working for the individual within its own context.

Meaningful learning occurs when science classrooms are places where learners engage with others (their peers and teachers) and are provided with opportunities to link what they already know, whatever its source, to new concepts being taught (Scott et al., 2011). The teacher's role is to provide learners with opportunities to work with their LPK and the new concepts (Driver et al., 1994) rather than focusing on the memorization of facts to be recalled in some form of assessment. The latter type of learning is usually short term and learners struggle to apply their knowledge to solve new problems (Mintzes & Wandersee, 1998).

2.4.2 Why should teachers worry about LPK?

Driver (1983)emphasizes the importance of teachers working with LPK. When learners link new science knowledge with their LPK, learning becomes meaningful. From a constructivist point of view, for learning to occur, new connections or links need to be made between prior knowledge and new ideas. Chiou and Anderson (2010) further advise teachers to explore learner's in-depth Science knowledge, as superficially learner's may be able to define terms and explain phenomena but scratching below the surface may uncover uncertainties and alternative conceptions.

2.4.3 Working with LPK

Ideally science classrooms are places where teachers provide opportunities for learners to actively engage with others, working between what they already know and new concepts, so that learners understand various phenomena. Not only does the teacher provide opportunities for this to happen they need to listen and question learner meaning all the time (Driver et al., 1994). Chi (2008) identifies three conditions that may occur when working with LPK. First, the learners may have no knowledge on the new concepts that need to be learnt. The LPK may be slightly related to what is being taught. Chi refers to this LPK as 'missing' and learning would consist of 'adding' new knowledge. In the second condition the LPK is 'incomplete' in that new concepts being taught 'fill the gaps'. The third condition occurs where the LPK conflicts with new concepts being taught. Here the goal of learning is to change the LPK to that which is currently believed to be correct knowledge. I discuss working with the alternative conceptions' learners have in the following section 2.4.4 (when LPK does not agree with school science).

Many teachers find working with LPK difficult. When teachers provide opportunities for learners to make their prior knowledge explicit, they may be opening a can of worms; some ideas they may have planned for whilst others are rather unique and novel (Ball & Bass, 2000). Now the teacher needs to decide on his/her next move: work with those contributions which move the lesson forward along its predetermined path; ignoring those contributions not planned for or to somehow interact with learner contributions.

Both Meyer (2004) and Mortimer and Scott (2003) found that experienced teachers worked more effectively with LPK than novice and preservice teachers. In Meyer's (2004) study, experienced teachers could move easily between LPK and science knowledge. This contrasted with the less experienced teachers whose approach was to "fill in the gaps" present in LPK. Brodie (2006) reported differences in the way experienced high school Mathematics teachers worked with LPK, based on how closely the LPK matched concepts that needed to be taught. Learners in a school that was under resourced tended to have poor LPK compared to learners from a well-resourced school. In the school where the LPK was poor, the teacher opted to use LPK to build concepts, in what Brodie referred to as a hierarchical structure. In the well-resourced school where LPK was more advanced and learner contributions numerous, the teacher worked with LPK learner contributions simultaneously, rather than using one concept to build on another, a parallel structure. Both lessons were regarded as being successful.

Instances have been reported where teachers do not work with LPK, choosing to ignore learner responses, particularly those that do not offer the teacher what s/he is looking for (Davis, 1997; Stears et al., 2003). However, where teachers work with the learner's everyday knowledge during their lessons, not only is there an increase in learner engagement, learners are also able to link their everyday way of knowing the world to science explanations (Stears et al., 2003).

Duit and Treagust (2012) state that many teachers are unfamiliar with current theories of teaching and learning. They see themselves as mediators of information and facts, where consideration of LPK is not needed. These teachers believe that successful learning results from good instruction. Yet much research particularly that focused on conceptual change has shown that meaningful learning occurs when teachers explore LPK.

2.4.4 When LPK does not agree with school Science.

As learners experience science in various ways, they come with conceptions and ideas about phenomena and concepts to be learnt some of which may agree with currently held science views and some which may not (Duit & Treagust, 2012). Many terms have been used by various authors to describe conceptions which are contrary to widely held current science knowledge: misconceptions(Bar & Travis, 1991), naïve conceptions (Hesse & Anderson, 1992), preconceptions (Benson, Wittrock, & Baur, 1993), alternative ideas (Sequeira & Leite, 1991) and alternative conceptions(Driver et al., 1994; Wandersee, Mintzes, & Novak, 1994). Wandersee et al. (1994) motivated using the term "alternative conceptions" as this acknowledges explanations learners have constructed for phenomena that they consider intelligible, and this term confers respect to the learner's way of thinking. It is for this reason I too will use the term 'alternative conception' to mean conception(s) learners have constructed that is/ are contrary to the science way of knowing.

Some alternative conceptions learners hold onto tenaciously and do not change despite school science instruction (Taber, 2001) whereas others are readily replaced by school science (Chi, 2008). Research focused on interacting with alternative conceptions in the classroom using conceptual change approaches may be categorized as being embedded in one of three theoretical frames: epistemological, ontological, and affective.

2.4.4.1 An Epistemological Perspective of Conceptual Change

Posner, Strike, Hewson, and Gertzog (1982) view learning as a rational activity. When new concepts are intelligible and rational, learners readily comprehend and accept the new ideas. Learners therefore make judgements on the available evidence of new concepts, as to whether these will form part of existing structures. Where existing concepts are consistent with the new concepts, the new concepts are assimilated. However, when existing concepts are inadequate in allowing the learners to fully make sense of the new concepts, then existing concepts will be reorganized or replaced to accommodate the new concepts (Posner et al., 1982). The same authors argue unless learners find new concepts intelligible (learner understands the concept), plausible (learner believes the concept to be true) and fruitful (concept can be used to solve novel problems) it will not be accommodated or assimilated into existing knowledge, i.e., meaningful learning will not take place. To assist learners in making sense of new concepts, teachers need to consider LPK as part of their teaching. Further, teachers should be aware of the diversity and complexity of alternative conceptions learners may have with a topic being taught, as these may surface during the lesson (Chiou & Anderson, 2010).

Hewson and Hewson (1983) suggest the following strategies teachers choose from when working with LPK. First, *integration*: the teacher integrates the new concepts with LPK. This is possible if the prior knowledge the learner has is consistent with accepted school science. Second, *differentiation:* Here LPK may not be harmonious with school science concepts, even though it may be related. Hewson and Hewson (1983) suggest learners need to be made aware that what is plausible in one in instance may not work in another instance. Third, *exchange*: exchange of conceptions should occur when LPK is contrary to new concepts to be taught. The teacher would need to show the learner how the prior knowledge contradicts the new concepts, and that the prior knowledge is not intelligible, plausible nor fruitful in a new situation. However, the new concept works well in new situations. Finally, *conceptual bridging*: in this instance the teacher would provide learners with a problem, which is solved using the new concepts being taught. Learners would understand the new concepts as they would be both plausible and fruitful in their solution to the problem. Findings from the Hewson and Hewson (1983) study showed when junior high school science teachers work with LPK, learning improved, compared with a control class where the teacher taught the same lessons, not paying much attention to learner prior knowledge.

Researchers who use epistemology to explain conceptual change place little emphasis on changes in the way learners view reality. I continue my discussion to consider an ontological perspective on conceptual change.

2.4.4.2 An Ontological Perspective on Conceptual Change

Chi (2008) argues that sometimes learners' alternative conceptions are readily changed by teaching that provides more plausible alternatives. She argues this happens when learners become aware of contradictions in their LPK and opt for the accepted science view having become aware of the inconsistencies in their way of thinking, much like Posner et al.'s (1982) epistemological perspective on conceptual change. However, instances occur where the alternative conception is robust and resistant to change. Chi argues that a reason for the alternative conception being resilient to change is because the learner has ontologically miscategorized the LPK. Chi describes how alternative conceptions may be placed in one category and the science knowledge occurs in another ontological category, now the LPK and the new science concepts conflict by ontology. In these instances, conceptual change requires a shift across ontological categories. An example of this type of change includes heat. Learners frequently consider heat to be a flowing liquid and teachers need to convince learners that heat is a form of energy. Chi advocates two instructional steps to overcome barriers to conceptual change for robust alternative conceptions: awareness that the conception is incorrectly categorized and second, knowledge about the concept's actual category.

I turn my literature review to consider the role of learner's motivational beliefs in working with learners' alternative conceptions.

2.4.4.3 Affective Aspects and Learner Characteristics of Conceptual Change

Pintrich, Marx, and Boyle (1993) stress the importance of learners' motivational beliefs in facilitating or hindering conceptual change. They argue that one of the reasons learners are unable to accommodate new knowledge is because much teaching only focuses on cognitive factors of conceptual change, ignoring learner' goals, expectations or needs. Taking on a constructivist position, the same authors contend that the processes influencing conceptual change include aspects that are personal, motivational, social, and historic. Not only is the conceptual change process influenced by individual beliefs, but also by the classroom context, being shaped by the nature of interactions that take place between the teacher and learner. Vygotsky's sociocultural theory recognizes the importance of these social interactions. Teachers who ignore the affective and social aspects of personal learning limit conceptual change in their classrooms (Duit & Treagust, 2012).

When teachers are aware of the knowledge learners may have when they enter the science classroom, they can adapt their teaching to engage learners, by developing instructional strategies allowing learners to make this knowledge explicit and link what they know to new concepts. In this way, it is hoped that alternative conceptions are challenged and abandoned. If learners are unable to link what they already to new concepts being taught it is likely that the learning concepts will be in isolation from what is already known, and meaningful learning will not occur.

Many teachers believe that successful learning is dependent on good instruction, ignoring or being ignorant of current theories of teaching and learning (Duit & Treagust, 2003). Some teachers are unaware of the role LPK plays in how learners make sense of and interpret new concepts, and do not explore this. In their study focused on how Physical Sciences teachers link new content with previously taught concepts, Mudadigwa and Msimanga (2019) concluded few opportunities were given for learners to explore how the new knowledge interacts with the existing conceptions learners have. Learner engagement in the link making process was low. It was the teachers who were the ones working with LPK, not the learners.

What is required when teachers work with LPK is for learners to be actively engaged in working with science concepts that provide opportunities for learners to make their LPK explicit. I turn my literature review to consider how teachers may create an atmosphere in the class which affords learners the opportunities to actively engage in the learning of new science concepts taking into account what they already know.

2.4.5 Working with LPK

Various teaching strategies have been proposed allowing teachers to explore LPK: These strategies include creating opportunities for alternative conceptions to surface and be challenged, providing opportunities for learners to actively engage in new concepts, and by asking questions focused on delving deeper into the meanings learners have made of concepts. I consider each of these teaching strategies.

2.4.5.1 Creating opportunities for assimilation and accommodation

When planning lessons, teachers should include activities with the purpose of creating cognitive conflict in learners (Posner et al., 1982). Teachers should allow time in their lessons to work with alternative conceptions learners have and then develop strategies to challenge these. Strategies should provide opportunities to using various modes of representation, for example, verbal, pictorial or mathematical.

2.4.5.2 Productive disciplinary engagement

Engle and Conant (2002) explain if teachers want learners to be productively engaged in their work then teachers need to consider the following four principles: problematize the content, give learners' authority to address the problems, hold learners accountable to others and provide learners with sufficient resources. I will consider each of the principles in a little more detail.

a. Problematizing the content.

When learners are trying to solve problems, they are required to organize their understandings, ask questions, and make sense of their ideas. Providing learners with activities in the form of problems generally results in them becoming active participants (Engle & Conant, 2002).

b. Giving learners' authority to address the problems.

In solving the problem learners, learners work with their peers to find a solution. The solution should require that learners generate knowledge and not merely regurgitate information from various resources. A requirement in achieving this is the explicit teaching of the following skills: argumentation and how effective groups function. Learners need to be informed of the importance of substantiating claims that they make. They also need to be made aware that they need to listen and respect the thoughts and opinions of other learners and by discussing opposing ideas they should find a solution for the problem (Engle & Conant, 2002).

c. Holding learners accountable to others.

When learners listen and consider their classmates opinions, they can engage in a discussion, persuading classmates of their understandings and views. In so doing members of the group are given an opportunity to be accountable and to take other viewpoints into account when making decisions on how to solve a problem. If teachers do not take learners views into account, and learners are unable to explain what and why they have an opinion Engle and Conant (2002) reason that it is probable that learners won't be fully engaged in the activity.

d. Providing learners with enough resources.

If teachers want learners to be actively engaged in solving a problem, then learners need support to develop and apply skills, knowledge, and representations. Learners need access to relevant materials and technologies. If learners are not provided with these resources it is likely that learners will either not engage in the activity or they will be frustrated and give up (Engle & Conant, 2002). Engle and Conant (2002) stress that teachers must not forget to give learners enough time to find a workable solution to their problem.

A final strategy teacher may use when exploring LPK, is to directly ask learners questions about their understanding of various concepts, during whole class teaching. I now consider the how the questions teachers ask may assist in making LPK explicit.

2.4.5.3 Providing Opportunities for Learner Talk

A common instructional approach used in high school science classrooms, is whole class discussions (Pimentel & Mc Neill, 2013). Such an approach results in much talk in the classroom. The talk in these types of lessons can be teacher talk or teacher-learner interactions. It is through talk that learners construct meaning (Chin, 2006; Mortimer & Scott, 2003). Talk not only allows learners to participate in various scientific practices like argumentation it also provides learners an opportunity to consider and change their views of science (Pimentel & Mc Neill, 2013). Talk allows learners to become active participants in their learning as they use the language of science (Mortimer & Scott, 2003). Aguiar, Mortimer, and Scott (2010) argue that not only does talk result in learners becoming actively involved in the learning of a topic, but learners also become motivated to make meaning of that which is being taught.

The role of the teacher in the promoting various types of discussions is essential in determining the type of science talk that happens in classrooms. It is the teacher who establishes the types of interactions taking place during a lesson(Mortimer & Scott, 2003). Often teachers use questions as a component of their class talk and it is these questions that decide on the nature of the talk during lessons (Chin, 2007). For instance when teachers ask learners a question, seeking a specific response, the right answer according to 'science', learners who respond correctly are applauded whilst those who respond with an unexpected answer are often made aware that their thinking or ideas are wrong (Mortimer & Scott, 2003).

This type of interaction common in many classrooms is the triadic IRE dialogue (Lemke, 1990; Pimentel & Mc Neill, 2013). This format has three moves: the teacher asks a question (I-initiate), the learner responds (R), concluded by the teacher evaluating the responses (E). The triadic dialogue is information seeking. The teacher asks a question already knowing the answer.

Often questions that are asked in IRE interactions are of a low order, requiring a predetermined short response from the learner (Chin, 2006). This type of interaction is restrictive on the learner's thinking, as responses are brief. The purpose of such interactions is to evaluate what the learner knows (Chin, 2006). When classroom discourse is dominated by IRE interactions, the teacher is situating themselves as the authority of science knowledge and strongly influences the way in which learners' talk science (Smart & Marshall, 2013).

Working with year 7 science teachers in Singapore, Chin (2006) reported, that where teachers changed the 'E' move to one of providing feedback (F), by for instance asking a probing question requiring learners to think more deeply, learners became engaged in more 'cognitively active roles'. For instance, learners were able to formulate hypotheses, make predictions, generate explanations, and draw conclusions. In some instances, instead of asking learners to explain their meaning, a teacher repeated a learner response, 'revoicing'. In so doing not only were learner's answers affirmed, but the response was heard by all learners, thereby making it common knowledge. Revoicing also provides an opportunity for a learner or a peer to co-construct a partial response. A third way teachers worked with the 'F' move was to use the learner response to build on concepts, allowing progress to a joint construction of concepts.

Where teachers explore learners understanding through probing, the triadic IRE interaction becomes an IRPRE interaction (Mortimer & Scott, 2003). Here the teacher probes (P) either the same learner or another learner, encouraging them to elaborate or explain their answer. The learner responds (R). The teacher may probe further before closing down the interaction with an evaluation (E) move (Mortimer & Scott, 2003). When IRPRE interactions occur, the teachers' focus is on exploring learners' thinking (Chin, 2007). In these instances, the questions teachers ask are open-ended, requiring learners to explain their meaning. Responses are full sentences (Chin, 2006). When teachers provide learners with a wait time before allowing them to answer questions, learners have time to clarify their thinking and to makes sense of the meanings of their peers I turn my review to consider why teachers ask the questions they do followed by analysis of the how teachers deal with learner responses.

a. *Questions Teachers Ask*

Teachers ask learners questions for various reasons; teachers may seek feedback on learner understanding. Questions may also be used to stimulate learners to think about a problem(Chin, 2007). If the purpose of the questions is to stimulate thinking or help the learner construct meaning of science concepts, the type of question teachers asked is significant. The cognitive processing learners engage in is dependent on the level at which the teacher asks the question (Chin, 2006). Low order questions result in learner responses that are single words and rely on recall, requiring little thought from the learner and provide the teacher with not much insight into learner understanding of a concept. This contrasts to higher order questions, that provide opportunities for learners to engage in higher order process such as explaining, predicting, justifying and hypothesizing (Smart & Marshall, 2013). When teachers ask questions that are open ended and respond to learners by encouraging learners to elaborate on their ideas and reasoning, learners engage in higher-order thinking (Chin, 2007). Working in two middle schools in the United States of America, Smart and Marshall (2013) noted the high prevalence of low-order questions teachers ask in science classrooms. This correlated with the learners' low cognitive engagement with science concepts.

By asking low order questions, the teacher is placed in an authoritative, evaluative role, as few responses are deemed correct (Pimentel & Mc Neill, 2013). Teachers seek these answers, disregarding ones that are considered incorrect. Where teachers are less confident with their content knowledge, they are more likely to rely on low order questions. As by asking high order questions, learners may respond with diverse and unplanned answers. Working with these unpredictable and varied responses requires teachers to have sound content knowledge (Smart & Marshall, 2013).

b. Working with Learner Responses

The type of cognitive processing learners engage in when answering questions is dependent on the type of question teachers ask (Smart & Marshall, 2013). Closed, low order questions, result in answers that are single words or phrases. Given the wide spread use of closed lower order questions teachers use, it is not surprising that Pimentel and Mc Neill (2013) reported that responses of learners in the five American high school science classes where they carried out their study were predominantly single words, phrases or statements, lacking explanation. This after teachers had attended a professional development programme focussed on supporting learners to explain their meaning fully.

Having responded to the question, the teacher now needs to decide what their next move will be. Various options are available for the teacher to decide on their next move; evaluate, elaborate, cut off, probe, or toss back. Where teachers opt to evaluate, elaborate or cut off a learner response, exploring learner understanding more deeply is stifled (Pimentel & Mc Neill, 2013). Having asked a question, and knowing what was planned, many teachers opt to evaluate learner answers as being correct or incorrect, without exploring learner answers further. Exploring learners understanding further may result in not completing the planned lesson (Chin, 2006). When teachers elaborate on a learner response there is little motivation for a learner to explain themselves, as the teacher does this. Sometimes teachers interrupt learners with a cut-off move as this allows the teacher keep control of the discussion.

When a teacher probes a learner to explain their meaning, so learner responses move to full sentences with reasons. In some instances, teachers may ask another learner in the class to expand on a learner's response in a 'toss back' move. Toss back moves tend to result in learners explaining their meaning in full sentences (Pimentel & Mc Neill, 2013). When teachers use probes and toss backs learners are encouraged to generate ideas, predict, brain storm ideas and draw conclusions (Chin, 2007). By using probes and toss backs, talk in the science classroom becomes productive and moves past basic recall of knowledge (Chin, 2007). However, many interactions in the classroom are void of probing or toss back moves (Mortimer & Scott, 2003).

How teachers work with learner responses is dependent on several factors. First the response given by the learner (Chin, 2006). Responses learners give are unpredictable and the teacher may not have planned for different ideas learners have. These places the teacher in a predicament as what to do; probe further and risk not knowing how to respond or evaluate the answer as being incorrect and moving on with the lesson. Second, the topic being addressed influences how teachers respond. If the topic is considered easy and straightforward the teacher may explore learner responses a little more compared to topics that are considered difficult with many alternative conceptions abounding. Teachers need sound content knowledge to work with varied learner responses. Whilst teachers may want more talk in their classes, some teachers feel they are unable to support the discourse (Pimentel & Mc Neill, 2013). Third, the ability of the learner. Where learners lack experience with science talk, they may be less motivated to respond (Pimentel & Mc Neill, 2013). Fourth, the teacher's preferred style of teaching and finally the curriculum time available (Chin, 2006). Working with learner responses and questions is time consuming. A tension exists between 'getting through the lesson' on time using an authoritative approach or to engage with the learners many differing voices (Aguiar et al., 2010; Van Zee, Iwasyk, Kurose, Simpson, & Wild, 2001). Some high school science teachers consider the focus of their teaching to be assessment of learners, therefore completing the curriculum on time for the end of year examinations, often supersedes the need to allocate time learners to talk science (Pimentel & Mc Neill, 2013).

The teacher is the person who has the controlling power in deciding the agenda and specifying what will be developed within the class. Whilst the teacher may at any time impose his/her authority, interactions in the classroom are dependent on participation of learners. Throughout the lesson, the teacher needs to be aware of and in tune with the learners understanding and their willingness to participate (Aguiar et al., 2010). Learners need to feel secure before they risk talking science. Learners who are active participants in talk in the classroom risk being regarded as a ‘boffin’ or being ‘stupid’ by their class mates (Aguiar et al., 2010). Teachers need to be sensitive to this.

Teachers responses to learner utterances are opportunities to support learners’ as they make meaning of science concepts. When teachers do this, they are responsible for assisting learners move through their ZPD.

LPK plays a paradoxical role in learning. From a constructivist perspective making sense of new knowledge is dependent on the sense learners have made on previously learnt knowledge. Where the prior knowledge learners possess agrees with currently held conceptions, learning is facilitated as there is a basis for understanding and judging the validity of solutions. However, where there is disagreement, the alternative conception is likely to impede learning. Effective science learning is therefore dependent on topics being taught in such a way that it is both relatable and understandable to learners in that it has considered existing cognitive structures learners may have. This requires teachers to explore and consider the knowledge that is brought to the class, when planning lessons. Teachers need to plan for possible alternative conceptions learners may have and create opportunities to challenge these (Pintrich et al., 1993).

In reality science is taught in high schools across continents as a transmissive pedagogy, where the content is decontextualized making science a difficult subject (Lyons, 2006). Sometimes teachers provide opportunities to link LPK gained from formal instruction or everyday experiences in their discourse. However, opportunities for learners to actively engage with their LPK are lacking (Mudadigwa & Msimanga, 2019). Duit and Treagust (2012) assert that not only are few teachers well informed on current teaching and learning. Many teachers do not value exploring LPK and believe that the good instruction will lead to meaningful learning. Yet research focused on conceptual change shows that these approaches are more effective than traditional transmission type lessons. There is a gap between research and practice. The same authors suggest teacher professional development (PD) focussed on making teachers aware of constructive and conceptual change views and possible instructional designs that are grounded in these views, may assist in narrowing the gap.

2.5 Teacher Professional Development

For my study I am using the term ‘teacher professional development’ (PD), as described by Joyce and Calhoun (2010) to mean, deliberate opportunities created by various organizations (schools or the education department), that have the purpose of developing teachers’ competences and expanding teachers' knowledge. At the heart of teacher PD is the hope that teachers participating in a programme, learn something new (content or new and different ways of teaching or learning) and that this results in a change in the way they teach, such that learner understanding of concepts being taught improves (Avalos, 2011). However, not all teachers are as enthusiastic towards attending, participating and implementing what the PD programmes advocate. Joyce and Calhoun (2010) describe four categories teachers may be placed in, in terms of their attitude towards professional growth. The first category termed, 'gourmet omnivores' are teachers who are pro-active in terms of their PD. They lookout for or generate opportunities for development, by exploiting a variety of sources within their social context. Teachers, classified as gourmet omnivores, tend to be natural leaders, although not all seek to lead. Second, 'active consumers', are teachers who like the gourmet omnivores seek opportunities for PD but are less pro-active. Third, 'passive consumers', these teachers are dependent on their PD being offered to them. They do not actively seek other growth opportunities and may respond to the PD if they find it stimulating. Most teachers fall in this category. Finally, 'reticent consumers', these are teachers who push away from PD. They may even discourage their peers from attending programmes. Reticent consumers tend to blame their context for their non-participation. Programme developers and facilitators of PD programmes, would do well to recognize the various categories of teachers participating in their programme, and realize that what they are presenting may not necessarily result in any teacher uptake or implementation. Nonetheless many teacher PD programmes have been used as vehicles to change and improve practices both locally (Reed, Davis, & Nyabanyaba, 2002) and internationally (Avalos, 2011).

2.5.1 Types of PD programmes

PD may take various forms: individual inquiry, personal services by peers, action research, open-ended learning communities and workshops (Joyce & Calhoun, 2010). Individual inquiry involves teachers acting individually, for instance, by furthering their studies through tertiary institutes. PD termed: 'personal services by peers' involves mentoring programmes involving teachers from the same school, or support staff, possibly from the district office. Ideas about teaching, learning, classroom management and the like are discussed in the mentoring programme. Action research allows to teachers to explore what they are doing and to offer descriptions and reasons for their practices. By its spiral nature of act, observe, plan and reflect, action research, provides teachers with a space to discuss and debate that which is being investigated. Through participation in action research, teachers become active participants in their PD. This contrasts with open-ended local learning communities, where a school-based teams assess and make decisions about that which needs improving. The last type of PD programme, workshops, are the most common type of PD. These are led by a facilitator disseminating information to teacher participants, in the hope that what is being imparted will be applied in the classroom (Richter, Kunter, Klusmann, Lüdtke, & Baumert, 2011).

Whilst Fullan (1991) argues that PD is cornerstone for improving and changing teachers' practice he also recognizes that many PD programmes have led to poor or no implementation in the classroom. In Fullan's words:

> *Nothing has promised so much and has been frustratingly wasteful as the 1000s of workshops and conferences that lead to no significant change in practice, when teachers return to their classrooms.*
>
> (Fullan, 1991, p. 315)

I continue my literature review to unpack some of the reasons given for the poor uptake from the PD to the classroom.

2.5.2 Unsuccessful uptake from professional development programmes

Cordingley et al. (2015) argue that unsuccessful uptake from teachers attending PD programmes, particularly those led by facilitators is due to the following three reasons: little consideration for the context, the workshop is short term, and no clear guidelines on how to implement the innovation. I will explore each of the reasons in a little more detail, starting with lack of consideration for the context of the teachers, learners and schools. When the content of the PD programme is designed by an outsider, they are influenced by their own beliefs and context. The programme presented may therefore be irrelevant to the context of participants (Fullan, 1991). Working with South African teachers, Walton, Nel, Muller and Lebeloane's (2014) paper titled: 'You can train us until we are blue in our faces we are still going to struggle,' describes how teachers' professional learning, is influenced by their context including: teachers past experiences, prior knowledge, their practices and beliefs. Unless these factors are considered when planning PD, it is unlikely that there will be sustained uptake from the programme, hence the title of the paper.

Second, stand-alone workshops are ineffective in the long term, as they do not offer follow up support (Fullan, 1991). In her study, working with science teachers, using a two day workshop that focused on making science content relevant to learners, by improving teachers' pedagogical content knowledge, Buma (2018) reported how the intervention was initially taken up with much enthusiasm, by the teachers. However, Buma recognized sustaining continued interest by teachers in using the intervention to develop future lessons was a challenge. Buma suggested a solution to assisting teachers in the long term may be found in creating communities of practice as both resources and experiences can be shared and are ongoing.

The last reason for unsuccessful uptake of what is presented at PD programmes, is that many PD programmes do not explicitly show teachers how to implement the content. As a result, what was learnt does not translate into changes in practice. The complexity of teacher PD should not be underestimated. PD involves both the cognitive and emotional involvement of teachers, both individually and collectively (Avalos, 2011). Having discussed reasons why implementation from PD programmes is poor, I now consider aspects of successful PD programmes.

2.5.3 Successful Professional Development Programmes

When identifying features present in successful PD programmes it is not surprising that Cordingley et al. (2015) stressed that developers consider the context of participants, as well as the length of the programme. PD programmes that take the teachers specific school context into account, considering teachers' experiences at the same time creating opportunities for teachers to work with the intervention tend to be more successful. Programmes that are longer term also result in better uptake. Four additional features Cordingley et al. (2015) identified as being part of successful PD programmes include: the content of the programme, the role of the facilitator, the role of participants and finally the development of PLCs.

Effective PD programmes allow teachers to easily introduce the intervention into their classes. When teachers can evaluate the impact of the intervention on their learners learning, it is likely that uptake from the programme will be sustained. The role of the facilitator needs to be emphasized. Where facilitators work with teachers as equals, it is possible to encourage participants to take over the leadership role. Once the leadership role shifts to a participant it is likely that the programme will persist. Working with primary school teachers from California in a study focused on literacy, Hollins, McIntyre, DeBose, Hollins, and Towner (2004), were encouraged with the probable sustainability of their intervention, when the principal of the school took over the role of facilitator, in the second year of the study.

When participants are provided with opportunities to collaborate, PD programmes tend to be successful. Durksen et al. (2017) highlighted the importance of collaborative supportive environments as providing spaces to nurture teacher motivation and efficacy. Teachers should be provided with opportunities to work together grappling with context specific problems. Collectively teachers can decide on possible solutions and then reflect on triumphs and challenges of the intervention. Working with in-service Home economics teachers in Finland, Kuusisaari (2014) reported how uptake from professional development focused on linking education theory (constructivism) to practice was dependent on teachers debating and questioning each other. Where there was little discussion when teachers agreed with a suggestion or ignored others, the group was less successful in developing activities and lesson plans that linked theory to practice. Fullan (1991) insists educational reform is dependent on teachers working collaboratively questioning, suggesting, and reflecting on their practice. By developing and doing new things together, change is likely to occur, as teachers gain new insights as to the reason for the change.

Working collaboratively reflecting on practice, empowers teachers to resolve their own difficulties, challenges and problems (Lin, Hong, Yang, & Lee, 2013). Many successful PD programmes result in the development of a PLC, where teachers can meet and deliberate on context specific issues. PLCs shift the responsibility for learning to the teachers and their changing needs, whereas PD usually refers to training opportunities arranged by experts for teachers (Durksen et al., 2017). By their nature PLCs have the potential to encourage learning, growth, and development within teachers.

2.6 Professional Learning Communities (PLCs)

For my study I have used the term 'PLC' as defined by Chauraya and Brodie (2017) where they describe a PLC as a space where teachers meet regularly with the purpose of changing practices through their collective interaction. PLCs have the potential to offer teachers contextually relevant and ongoing support (Walton et al., 2014). When teachers work collaboratively, teachers can create good resources a lot quicker, than working alone, as they have access to the expertise of others (Fullan, 1991).

Brodie (2013) has argued successful PLCs possess the following four features: first, learning is professional in that data comes from teachers own experiences and is related to the school context and various forms of knowledge and research. Sharing similar experiences, allows teachers to critically reflect (Vescio, Ross, & Adams, 2008). Second, a crucial element of successful PLCs, is the purpose of the PLC (Brodie, 2013). Careful consideration needs to be given to what the community of teachers is inquiring into and or what are they learning. Teachers must be provided with opportunities to reflect on various aspects of their teaching, or on learners' understanding. Third, working collaboratively in a PLC needs support by leaders, both from the Education Department and school; management (principals) and curriculum leaders (heads of department). Teacher participation in a PLC is endorsed by the South African Department of Education as a means of enhancing teacher professional development (DoE, 2011).

Finally, successful PLCs are dependent on the facilitator. Facilitators require varied skills, from design and implementation of interventions, to managing the collaborative process. It is essential that facilitators ensure the PLC has a safe, trusted environment where participants are respected, and are able to grow and learn together (Brodie, 2013). Achieving this, requires facilitators that are motivated and committed to support and encourage teachers in a variety of ways (Bolam, Mahon, Stoll, Thomas, & Wallace, 2005). A study conducted by Walker (1994), in the late 1980s described how primary school teachers from Cape Town, participating in her action research project, initially struggled to discuss and debate in meetings. Throughout the two-year project teachers were supported and respected. With continued participation, Walker reported that teachers became confident in their ability to suggest changes to their practice to improve their teaching. More recently a study by Feldman and Fataar (2014) working with BEd Honours students from Cape Town, in a PLC concluded that students required a safe space to reflect on classroom practice. Initially discussions were 'messy and recursive'. Successful PLCs provide participants with a supportive and open atmosphere (Durksen et al., 2017). Without good leadership a PLC will not function effectively (Bolam et al., 2005). Once established a PLC provides both a safe and challenging space for professional learning (Brodie, 2013).

Functional PLCs are not easy to get going and sustain. They require thoughtful planning and continued commitment by members. Bolam et al. (2005) identified various factors that inhibit successful PLCs: first some teachers' are resistant to embrace change. Joyce and Calhoun (2010) described such teachers as 'reticent consumers.' Second staff turnover, having new teachers joining PLCs makes it difficult to encourage and develop trust within the group. Third, policies affecting resources and budgets. Discussions may become rather tiresome and unproductive when they are about debating how resources are used or money spent. The value of participating in a PLC may then be questioned.

A component of successful PLCs, relevant to my project is providing teachers with opportunities to reflect on their shared practice. Schőn (1991) defined reflective practice as the way in which professionals become mindful of their tacit knowledge and learn from their experiences. I turn my literature review to exploring reflection: why reflection is significant, when does reflection take place, levels of teachers' reflection and end by considering reasons why some teachers struggle to reflect on their practice.

2.7 Teacher Reflective Practice

Reflecting on classroom practice is significant for the following reasons: reflection allows for analysis and critical evaluation of both the teacher and subject matter as well as supporting professional growth (Calderhead, 1988). By questioning their practice, opportunities are created for teachers to consider new ways of teaching and to solve problems in novel ways (Postholm, 2008). When teachers reflect on their teaching, opportunities are created for teachers to become more skilled and better teachers. As Zeichner and Liston (2013, p. xvii) claim,

> *'It is through reflection on our teaching that we become more skilled, more capable and in general better teachers.'*

As such reflecting on practice and past experiences, is a component of good teaching (Zeichner & Liston, 2013). Korthagen, Kessels, Koster, Lagerwerf, and Wubbels (2001) emphasize that it is past experiences that shape teachers' behaviour, by creating and developing mental structures. It is through reflection that teachers can influence the mental structures that guide their behaviour. The same authors described the ALACT model of reflection, a series of five steps required for effective reflection: 1. **A**ction, 2. **L**ooking back on action, 3. **A**wareness of essential aspects, 4. **C**reating alternative methods of action and finally **T**rial (see Figure 2).

The first step in the ALACT model of reflection, is that an action needs to have happened (**A**). It is then possible for teachers to look **(L)** back on the action, particularly when something unexpected happened and/ or the goal of the action was not achieved. This is followed by the teacher reflecting on what happened, awareness of essential aspects (**A),** step 3. The teacher would consider reasons why the incident happened, or why learners did not understand concepts being taught. For instance, learners may not follow instructions, when given a box containing electrical components. Learners excitedly build a closed circuit such that they get a lamp to glow, completely ignoring activities that need to be completed.

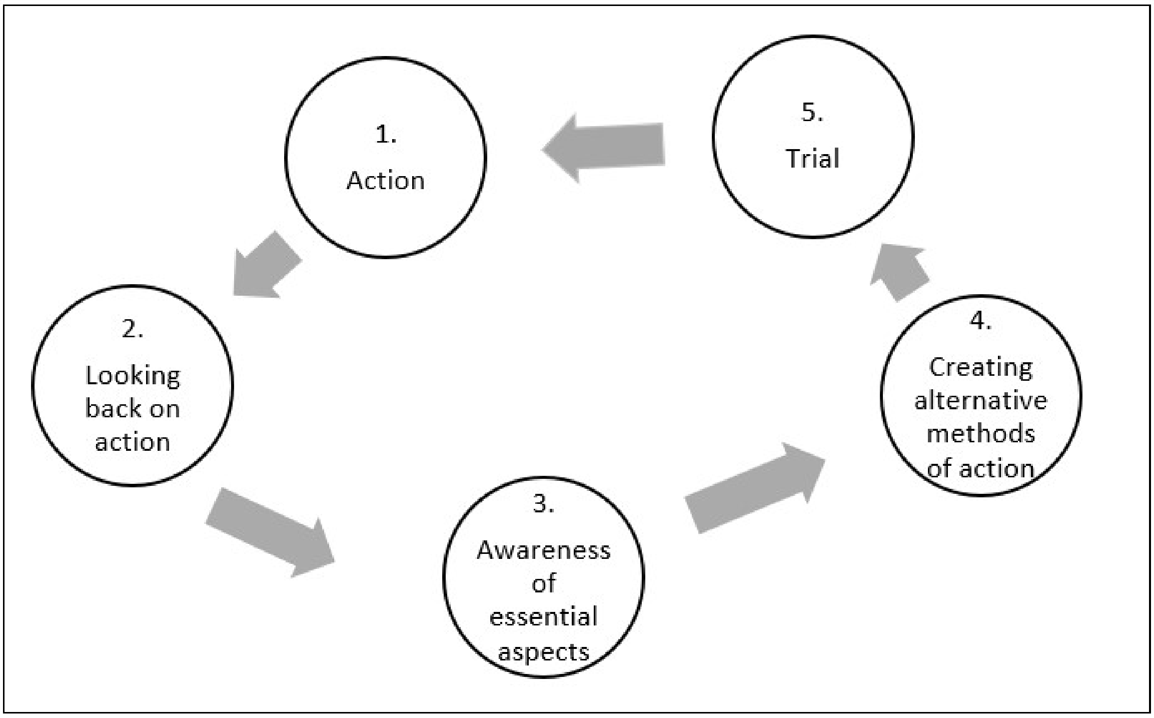


Figure 2 The ALACT Model of Reflection (Korthagen et al., 2001, p. 44)

Having become aware of why things did not play out the way they were planned and being able to predict similar actions in the future the teacher moves into stage four of the ALACT cycle, ‘creating alternative methods of action' **(C)**. In this stage teachers, think about learners’ understandings and consider various teaching strategies to promote meaningful learning going forward. Considering, the example given earlier, if teachers can predict that learners want to ‘get a lamp to glow’ when given an electrical kit. Teachers can plan for this by organizing activities such that the first activity requires learners to build a closed circuit with a lamp. Having built the circuit, learners can then move onto other activities.

The final stage in the ALACT cycle requires that the teacher puts into action the new teaching strategy, trial **(T)**. This will then start the ALACT cycle of reflection again, where teachers will contemplate ‘actions’ that did not give the planned result.

Korthagen et al. (2001) argue that the fear of change, often leads to resistance when teachers are in stages 3 and 4. This may lead to teachers feeling insecure and confused. However, as they emphasize, reflection is central to good teaching. Having discussed the various steps required for effective reflection, I turn my discussion to consider when teachers reflect.

2.7.1 Reflection in-action and on-action

Teachers may either reflect on an action immediately whilst teaching or later once the lesson is over. Schőn (1991) differentiates between reflection-in-action and reflection-on-action. Reflection-in-action arises as teachers reflect on their actions as they occur, during lessons. This contrasts with reflection-on-action, where teachers reflect on practices once, they have happened. Working with maths, science and English teachers from primary and high (rural and urban) schools, Reed et al. (2002) reported that it was teachers with sound content and pedagogical knowledge who were able to reflect both in-action and on-action. For my study I am reporting on reflection-on-action, as teachers reflected on their lessons, having taught them.

2.7.2 Reflection is not as easy as it seems.

Whilst research reports on improvements in practice following reflection (Cordingley et al., 2015; Durksen et al., 2017), not all teachers find reflecting on practice easy and struggle to reflect (Khan, Fazal, & Amin, 2014; Ono & Ferreira, 2010). Hatton and Smith (1995) list several reasons why pre-service teachers struggled to reflect. The first barrier arises as reflection is perceived as an academic pursuit, and not something practicing teachers do. Teaching is regarded as being concerned about the immediate present and realistic actions which needed to be taken in the now. Reflection may be regarded as an unnecessary diversion from mastering skills that are considered important, such as teaching of content. The second barrier hindering reflection is time and opportunity for development of both metateaching and metacognition skills. The third barrier hindering teacher reflection are the reactions to the demands for reflection that require attention. Exposing how somtheing is perceived, may leave the person feeling vulnerable. Hatton and Smith (1995) suggest that pre-service teachers move away from reflecting on their own, and rather do so in safe community of peers or critical friends. By working in a community of critical friends, feelings of inadequacy may be allieviated.

Studies from South Africa have indicated that there are instances where South African teachers struggle to reflect. Working with Mpumalanga teachers using lesson study to reflect on practice Ono and Ferreira (2010) reported how initially teachers had difficulty reflecting, beyond concerns of curriculum completion. A second paper (Chikamori, Ono, & Rogan, 2013), described how both teacher participation and the level at which teachers reflected increased with successive reflective cycles, particularly in meetings scheduled prior to teachers teaching the lesson. However, most reflections were voiced by the research leadership team, with teachers' reflections making up less than 5% of the total reflections. The authors noted that had the leadership team not stepped up to lead reflections during meetings, it was likely that teachers' reflective practice would not have increased. An earlier study described by Walker (1994) using an action research, research design, working with teachers form a township in Cape Town, highlighted the vital role of a facilitator in providing support to teachers as they reflected on their practice.

The crucial role of a facilitator in assisting teachers with reflection was stressed by Fazio (2009) in his study involving Canadian science teachers. Fazio (2009) recognized the essential role of the facilitator in organizing and providing opportunities for teachers to reflect on their classroom practice. It was by working collaboratively using group discussions where teachers were able to reflect, moving their concerns from that which was contextually based to rather focus on their curricular actions. Collaborative reflection allows teachers to work together, providing opportunities for discussions and support, such that teachers start to consider aspects of their practice that they may have not been aware of or even ignored (Lin et al., 2013).
Having considered some of the difficulty's teachers face when reflecting on their practice, I turn my discussion to consider aspects of teachers' reflective practice.

2.7.3 Levels of Reflective Practice

Various theorists have put forward diverse ways to categorize, analyse and or measure the nature and or quality of reflection. Most studies have been concerned with the reflections made by pre-service teachers. For instance, Hatton and Smith (1995) analysed written reflections from 4th year pre-service Australian teachers and characterized four kinds of reflection based on written reflections: first descriptive writing, second descriptive reflection, third dialogic reflection and finally critical reflection. Reflections were coded as descriptive reflection where pre-service teachers had endeavoured to provide reasons (either from literature or personal experience) for an event. Dialogic reflections were those reflections where the pre-service teacher explored many reasons for an incident, going back and forth. Critical reflections were those which considered the broader historical, political and/or social contexts for an event.

Several studies focussed on teacher (and pre-service teacher) reflections are grounded in the writings of Van Manen (1977) and his three 'levels of reflectivity': level one, technical rationality; level two, practical action and level three, critical reflection. Reflection at the level of 'technical rationality' is primarily concerned with efficiently and effectively applying educational knowledge with the purpose of achieving accepted end goals. The end goals are not open to change or criticism. The context of the classroom, school or community are not considered. At the second level of reflectivity, 'practical action', Van Manen asserts that reflections are concerned with explanations to clarify problems. Actions are linked to value commitments and the teacher debates on competing educational goals. This kind of reflection recognizes that meanings are not absolute, but are embedded in and negotiated, through language. The third level of reflectivity, 'critical reflection' incorporates ethical and moral criteria into contemplating practical action. Here the teacher would be concerned with asking questions about how educational goals and activities are mediated considering concerns for justice and equity. Consideration is given to both the teaching goals and the surrounding contexts. Using Van Manen's level of reflectivity, Dinkelman (2000) worked with pre-service teachers in Michigan, exploring whether they could 'critically reflect' during their teaching experience. He distinguished between: 'critical reflection; and 'critically reflective teaching' where the former referred to reflection that was concerned with contemplating the relationship existing between a democratic, just and equitable society with educational practice. 'Critically reflective teaching' he defined as the instructional practice informed by critical reflection. Dinkelman (2000) stated that from the start of data collection, all of his participants (three pre-service teachers) were concerned about the practical aspect of teaching as well as being capable of critical reflection. He attributed the ability of the pre-service teachers to critically reflect, to his role as supervising teacher, where pre-service teachers' attention was continuously drawn to social issues related to gender, equity and democracy. The pre-service teachers had indicated that their co-operating teachers at the school where they were placed for teaching experience, were not helpful in encouraging them to reflect on moral and ethical dimensions of educational practices.

Zeichner and Liston (1987) used Van Manen's (1977) levels of reflectivity, to develop their three levels of reflection: technician, craftsperson and moral craftsperson. Reflection is at the low 'technician level' when the focus of the reflection considers what others have stated needs to be done, for instance curriculum completion. At the next level of reflection: 'craftsperson', the teacher reflects on what education goals are and how well these are being achieved. When a teacher considers the context and contemplates the moral and ethical implications of actions the teacher is reflecting at what Zeichner and Liston term ‘moral craftsperson’ level.

Using Zeichner and Liston’s three levels of reflection, O’Sullivan (2002) argued transferring western levels of reflection to developing country contexts, was not always possible. She reported on the difficulty Namibian teachers faced when asked to reflect on their practice. Having been trained in an apartheid system, teachers were accustomed to being told what to do and were unfamiliar with having their ideas valued. Further, teachers professional training was lacking, in that teachers were unaware how to reflect to improve practice. Teachers were unable to analyze their practice and consider why certain events occurred and how to correct them. With continued opportunities to reflect, asking ‘why’ and ‘how’ questions, Namibian teachers became familiar with reflective approaches, their confidence increased, and they realized that their contributions were valued, by the research team and their peers. By the end of the study, when prompted, teachers began raising issues with their lessons.

As the Namibian teachers were reflecting at a level below Zeichner and Liston’s ‘technician level’, O’Sullivan introduced a lower level of reflection, ‘basic technical awareness’, where teachers put forward something needing restructuring, but could not suggest solutions to the problem. O’Sullivan concluded that teachers’ reflective skills can be developed as a means of improving their teaching. She stressed that developing teachers’ reflective skills is only possible if the researcher or facilitator starts where the teachers’ level of reflection is at. In her study the teachers were at the low ‘basic technical awareness’ level of reflection, where teachers were able to identify problems in practice but not suggest solutions. Using a structured reflection approach, there was a significant improvement in the level at which teachers reflected, which lead to better teaching in the classroom. As noted by O’ Sullivan there is an underlying social constructivist approach to learning using this approach, where interaction with others is important. Here, more skilled individuals, supported teachers from how they were able to reflect at the start of the study to the learning of new reflective skills throughout the study.

2.8 Conclusion

In this Chapter I have discussed how my study is located within literature using Vygotsky’s socio-cultural theory as a lens to guide my project. Using the socio-cultural theory, I have discussed how learning first occurs on the social interpsychological plane and through a process of internalization gains meaning on the intrapsychological plane. It is by using the tools of language that internalization is made possible. The importance of bringing together the ‘spontaneous’ knowledge’ (LPK) with ‘science’ knowledge (curricular content knowledge) was highlighted. I have also discussed the notion of the ZPD, where a more capable other mediates learning, taking learners from what they are able to do on their own, to a what they can achieve with assistance. Whilst I have discussed the ZPD in terms of learners, my study also focused on what teachers do and their learning, and as such have reported on two papers who transferred Vygotsky’s ZPD, to teachers (Jones et al., 1998; Kuusisaari, 2014).

In answering my first two research questions: In their baseline teaching practices how do teachers interact with LPK; and why do teachers interact with LPK the way they do, I unpacked literature focused on LPK. First, I provided a definition for LPK and then considered various sources of this knowledge. I have argued the essential role LPK plays in learners making meaning of new concepts. An aspect of good teaching is to provide opportunities for learners to make their LPK explicit. Doing this brings with it possible challenges, as learner responses may be diverse and unplanned. Where the LPK agrees with science concepts, teaching and learning will move forward unhindered. However, when the two disagree, the teacher should provide opportunities to challenge the alternative conceptions. Failure for the learner to reconcile their existing knowledge with new knowledge may result in the learner creating further alternative conceptions, or not linking new concepts to that which they know. Thus, the importance of exploring LPK was highlighted and three ways of achieving this were discussed: creating opportunities for assimilation and accommodation, productive disciplinary engagement and asking questions.

I continued the chapter by reviewing literature that focuses on teachers’ reflective practice. Whilst the focus of my project was concerned with exploring how teachers interact with LPK, reflection on lessons is essential to improve interactions, as teachers become mindful of what has taken place. When teachers reflect on their practice’s opportunities are created for teachers to consider triumphs and challenges in their lessons and adjust how they do things going forward. Whilst it makes sense for teachers to reflect on what has happened, I have discussed studies where teachers have struggled to reflect.

PD programmes may be used to assist teachers improve their reflective practice. Joyce and Calhoun (2010) caution PD developers assuming all teachers will be eager to attend or participate in PD programmes: some teachers are super keen and actively seek out programmes many attend PD programmes that come their way, some more actively than others. Then there are a final group of teachers who find no value in attending PD programme.

Bearing in mind that not all teachers are over enthused at attending PD programmes, I developed an argument for the type of PD programme that encourages active participation by teachers as they reflect on their practice. PD comes in various forms with workshops being the most common. Yet it has been reported that workshop type PD programmes do not necessarily lead to effective uptake and implementation by teachers. Buma (2018) reported that participants that attended her workshop initially did so much enthusiasm, only to have that wane with time. Studies have found that PD programmes that are long term, take the context of participants into account and include explicit instruction on how to implement what is being taught, tend to be more successful in their uptake by teachers. I argue that where teachers meet as a PLC, successful changes in teaching have been noted, since amongst other factors the context is considered in the PD. PLCs tend to meet for a longer time compared to short once off workshops,

I continued my literature review to describe how PLCs provide spaces where teachers can work collaboratively and receive the necessary support to improve their reflective practice. The role of leader of the PLC was been highlighted as being vital in ensuring the success of a PLC.

I then considered the role of the leader in managing the PLC. Socio-cultural theory emphasizes that a more capable person is required to mediate the process moving people (in this instance teachers) from what they can do on their own to what they cannot. I reviewed literature that reported how leaders interacted with teachers in a range of studies. Some studies reported on the research leadership being most active participants in sessions (Chikamori et al., 2013) whilst others describe the research leadership team continually supporting and encouraging participants in their reflective practice (Walker, 1994). In some studies, the role of the leader was taken by participants (Kuusisaari, 2014; Wilburn, 2019).

I end the Chapter by considering various levels at which teachers reflect. Research conducted in Southern Africa by Walker (1994) and O'Sullivan (2002) report how with continued support and over a long period teachers reflective practice improved. O'Sullivan measured teachers' reflective practice using Zeichner and Liston's 'levels of reflection': technician, craftsperson, and moral craftsperson. Teachers in her study reflected at a level lower than that of technician and she described these teachers as reflecting with 'basic technical awareness'. I described the levels of reflection, as these are useful in my study as I seek to answer my third research question: what influence does attendance at successive PLC meetings focused on reflecting how teachers engage with LPK, have on teacher participation within the PLC and the level at which they reflect? In the next chapter I discuss the design of my research and unpack the methodology used to collect and analyze data that will answer my research question.

Chapter 3 Methodology

3.1 Introduction

Methodology has been defined as 'the overall approach to research linked to the paradigm or theoretical framework',(Mackenzie & Knipe, 2006, p. 198). I start the chapter by explaining why I chose the interpretivist research paradigm to conduct this research in. I argue why using practical action research, was a suitable research design that allowed me to answer my research question: how do interactions concerned with exploring learner prior knowledge change, as teachers participate in a PLC focused on encouraging learners to make their knowledge explicit? I describe the context where data were collected and provide detail of participants: both teachers and learners. As I was participant in the research and that data were collected at the school where I am employed, ethical considerations are discussed following the description of participants. I am upfront of my position in the school and what measures were taken to respect participants throughout the research process.

I continue the chapter explaining methods of data collection, which included interviews with teachers, observations and video recordings of lessons, audio recordings of reflect and plan PLC meetings, as well as field notes written throughout the project. I go on to describe what emerged as the project spiraled through the five cycles of the action research design, as teachers endeavoured to consider how to effectively engage with LPK over two years. Various analytical frameworks were used to make sense of the data. In answering the first two research sub questions I made use of Mortimer and Scott's (2003) tool for 'Analysing meaning making interactions in science classrooms', Pimentel and Mc Neill's (2013) types of 'teacher moves' and 'learner responses'. My first research question was concerned with investigating: how teachers interact with LPK in their baseline lessons, and the second research sub question considered why teachers interact with LPK the way they do. To guide how I analysed my data when answering my third research sub question: what influence does attendance at successive PLC meetings focused on reflecting how teachers engage with LPK, have on teacher participation and the level of reflection, I used a hybrid of Zeichner and Liston's (1987) levels of teacher reflection, with O'Sullivan's (2002) low level of teacher of reflection. Using this hybrid of levels of teacher reflection, I was able to code the level at which teacher reflected during PLC meetings. I end the chapter discussing issues related to enhancing the validity of the study.

3.2 Research Paradigm

Doing research is surely about uncovering the truth of a phenomenon. How does a researcher get to the truth of that phenomenon? How a researcher views “truth”, will determine what paradigm they work within. A paradigm represents a way of looking at what counts as correct and approved knowledge. Researchers working within the same paradigm share a belief system and set of principles. They agree on what phenomena can be investigated and how this should be carried out (Cohen, Manion, & Morrison, 2011). Put simply, researchers working within the same paradigm share similar assumptions, hypotheses and approaches to research (Okeke & Van Wyk, 2016). There are many varied paradigms where researchers conduct their work, at the two extremes would be positivist and interpretivist paradigms.

Positivist researchers contend that it is through observation, logical reasoning and verified empirical data where knowledge gains its meaning (Cohen et al., 2011). Such knowledge is considered objective, scientific and is well integrated within Western culture. The interpretivist paradigm focuses on “the localized meanings of human experience” (Treagust, Won, & Duit, 2014, p. 7). The ontological assumptions within the interpretivist paradigm emphasize that reality is essentially ‘mental” and ‘perceived” (Hudson & Ozanne, 1988). Reality is socially constructed and consequently multiple realities exist due to various perspectives both individual and those held by a group of people (Okeke & Van Wyk, 2016). As a result, the context of the phenomenon being investigated is important, since people construct their reality and its meaning based on their context (Hudson & Ozanne, 1988). This is in contrast to positivists, who view reality as being objective and existing independently of the researcher (Okeke & Van Wyk, 2016).

Epistemological beliefs within the interpretivist paradigm are concerned with how the researcher goes about uncovering this knowledge and what counts as knowledge. Whilst positivists seek to make generalizations that can be applied to a number of situations in varied contexts and that hold true over time, interpretivists seek to uncover meanings, reasons and motives that are bound in context and time. It is unlikely that interpretivists will make generalizations, rather interpretivists are concerned about understanding a particular phenomenon (Hudson & Ozanne, 1988). Interpretivists make sense of the situated meanings; participants make out of their context in a given time.

In contrast to positivist and interpretivist paradigms, which seek to understand and explain phenomena through different lenses, critical theory is a paradigm located in social theory.

Critical theory is orientated towards moving a society to a democracy, where all members are equal. Critical theory seeks to promote emancipation, redressing issues around inequalities and disempowerment (Cohen et al., 2011).

I have chosen to work within the interpretivist paradigm as my research describes people's experiences in detail, I am not attempting to make broad generalizations, nor am I seeking to address issues of inequalities or oppression. Treagust et al. (2014) advocate interpretivist researchers spend an extended period at the research site, allowing the researchers to develop a good understanding of the educational phenomenon being investigated, at the same time building up a good rapport with the participants. I have been working at the school where the research was conducted for 25 years and am therefore aware of the context. I have worked closely with participants prior to the research and have developed good rapport with all. Geertz (1973) argues when researchers explore participant meaning it is possible for the researcher to offer a "thick description" of a situation, within a certain context. However, Treagust et al. (2014) caution researchers working within the interpretivist paradigm to be aware of the many levels of subjectivity that may occur, when working closely with participants. For instance, subjectivity may creep in: within the social interactions between participants; interactions between the researcher and participants, and analyzing data and drawing conclusions. This leads me to a short discussion on the axiological assumptions interpretivists work with.

Axiology is concerned with issues related to values and ethics (Okeke & Van Wyk, 2016). As the interpretivist researcher works with data that is value-laden in nature, s/he needs to be upfront about her/his own values and possible biases (Okeke & Van Wyk, 2016). Throughout the project, from the proposal, data collection, data analysis and writing up, I have been aware of the how close I am to the project: both participant and researcher in a qualitative study, using a practical action research design. I have attempted to be candid about possible biases I may have throughout the project. Ethical considerations and issues related to validity are discussed in this chapter, Section 3.5 (page 63) and section 3.11 (page 90), respectively. I continue by arguing why practical action research was a suitable research design to use to answer my research question.

3.3 Research Design: Action Research

3.3.1 Introduction

One of the principles of action research is that it allows participants to solve problems together, whilst at the same time enhancing competencies (Cohen et al., 2011; Creswell, 2012). Action research is characterized by its orderly cyclical procedures used to gather data on a specific problem. Having gathered data, solutions to the problem are suggested and implemented. Solutions are reflected on and if necessary changes are made (Creswell, 2012). Through reflection, opportunities are created for participants to improve teaching practices (Kemmis & McTaggart, 2005).

The reasons why I chose an action research, research design for my project were the following:

(a) Action research promotes change in classroom teaching practices (Cohen et al., 2011; Creswell, 2012). Through continued collaborative reflection and planning of lessons, teachers are likely to try different approaches to teaching concepts to help improve learner understanding.

(b) Action research provides an opportunity for professional development, through collaborative learning. By collaborating teachers are given an opportunity to reflect on practices and draw on their own experience and content knowledge (McNiff, 2010).

(c) Action research is a useful way to conduct research in that it is seen to bridge the gap between research and practice. Various reasons have been given for the gap that exists in educational research and practices: firstly, teachers do not find research convincing (Kennedy, 1997). Results are sometimes inconclusive, evidence is lacking or ambiguous and data are regarded as being invalid and unreliable (Broekkamp & van Hout-Wolters, 2007). Secondly research is regarded as being irrelevant to practice and does not address teacher's problems (Kennedy, 1997). Finally teachers do not have access to the research (Kennedy, 1997). The lack of access to research may be physical access, i.e., the teacher cannot locate research papers, and/or conceptual access where teachers' beliefs play an important role in deciding whether to change their practice or not. I did not want teachers in my study to see my research purely as an academic pursuit, with little relevance to their own context.

(d) Since action research allows the researcher to work collaboratively with teachers to solve a specific problem (Mc Millan & Schumacher, 2010), it was hoped that participating teachers would see my research as not taking from them for my own research purposes, but rather as an opportunity to improve their (and my own) teaching practices through observation, reflection, planning and action.

3.3.2 Characteristics of Action Research

Action research is cyclical in nature with each cycle spiraling into the next cycle (Cohen et al., 2011). A cycle of action research includes the following phases: plan, act, observe and reflect (see Figure 3). In the first cycle classroom lessons are taught (act 1) and observed (observe 1). This is followed by reflection of the lesson (reflect 1), where the teaching is analyzed. Here aspects of what is happening and why it is happening are looked at. The first phase, plan (plan 2) of the next cycle occurs when participants plan how to implement an intervention. The next phase act 2 occurs when teachers implement plan 2 in their classrooms. Act 2 is followed by reflection, (reflect 2) (McNiff, 2010). During reflect 2, participants consider how well their intervention solved the problem identified in reflect 1 and planned for in plan 2 (Cohen et al., 2011; Riding, Fowell, & Levy, 1995).

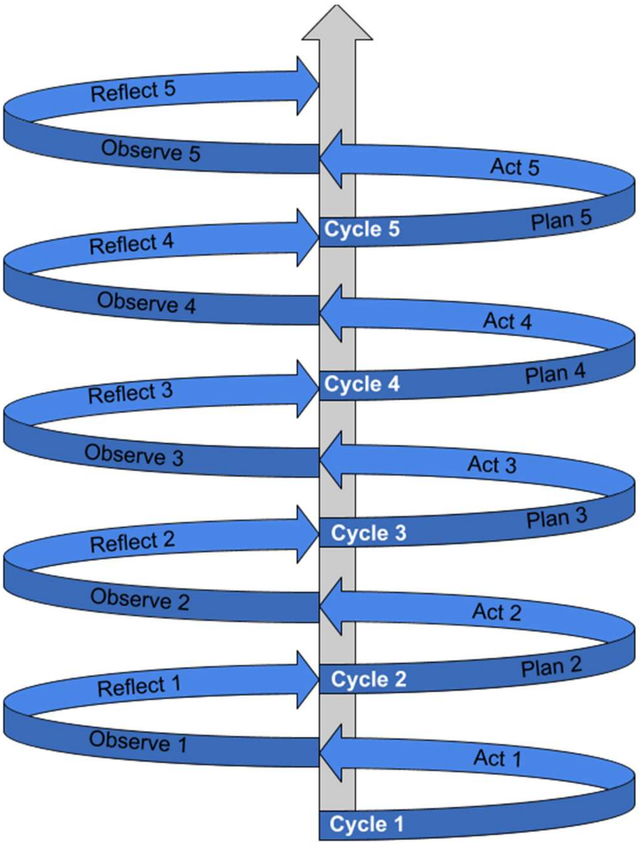


Figure 3 Action research interacting cycles.

Having reflected, teachers plan (plan 3) what changes need to be made to improve teaching. Plan 3 marks the start of the next cycle: cycle 3. Implementation of that which was planned for moves the research to the act 3. Observing teachers implement the revised intervention (observe 3), is followed by reflection, (reflect 3).

Teachers continue with the act, observe, reflect and plan phases of successive cycles until they are satisfied their intervention is successful, as it has been tweaked through cycles (Riding et al., 1995).

3.3.3 Types of Action Research

Creswell (2012)identifies two types of action research: participatory action research and practical action research. Various terms have been used for these types of action research, for instance: participatory action research has been referred to as critical action research by Mills (2011) and practical action research as classroom action research by Kemmis and McTaggart (2005). I will use the terms used by Creswell. Participatory action research is focused on large communities where the focus of the research is on emancipation or change in the community. There is a shared interest between researchers and community members that focuses on liberation of members of the community from the constrains of unjust traditions, habits and/or bureaucracy (Mills, 2011). Analysis of the social problems is community based with a focus on community action to solve the identified problems (Kemmis & McTaggart, 2005).

The research design used in my study was practical action research as I worked with few participants within a school context (Creswell, 2012). I was not seeking to emancipate a community. Practical action research is concerned with teachers reflecting, planning and reworking lessons, allowing improvement in their teaching resulting in improvement in learner understanding (Creswell, 2012; Mc Millan & Schumacher, 2010).

Two criteria necessary for practical action research are, firstly that the study has a narrow focus and secondly that the study is small scale (Mills, 2011). My research was focused on the specific issue of exploring how do interactions concerned with exploring learner prior knowledge change, as teachers participate in a PLC focused on encouraging learners to make their knowledge explicit? It had a narrow focus and was small scale, only four teachers, teaching at the same school were participants.

3.3.4 Action Research and My Research Project.

Four Grade 8 Natural Sciences teachers collected data over two years, using a practical action research design. A total of five cycles have been completed: Cycles 1, 2 and 3 in year 1 and Cycles 4 and 5 in year 2. Cycle 1 focused on baseline teacher practices. Cycles 2 and 4 were concerned with the same content: 'Effects of Electric Current' (EoEC) in year 1 and year 2, respectively. Cycles 3 and 5 were concerned with the content: 'Light' in each year of the study (see Figure 4). Figure 4 shows how data collected from each cycle was used to answer my three research sub questions.

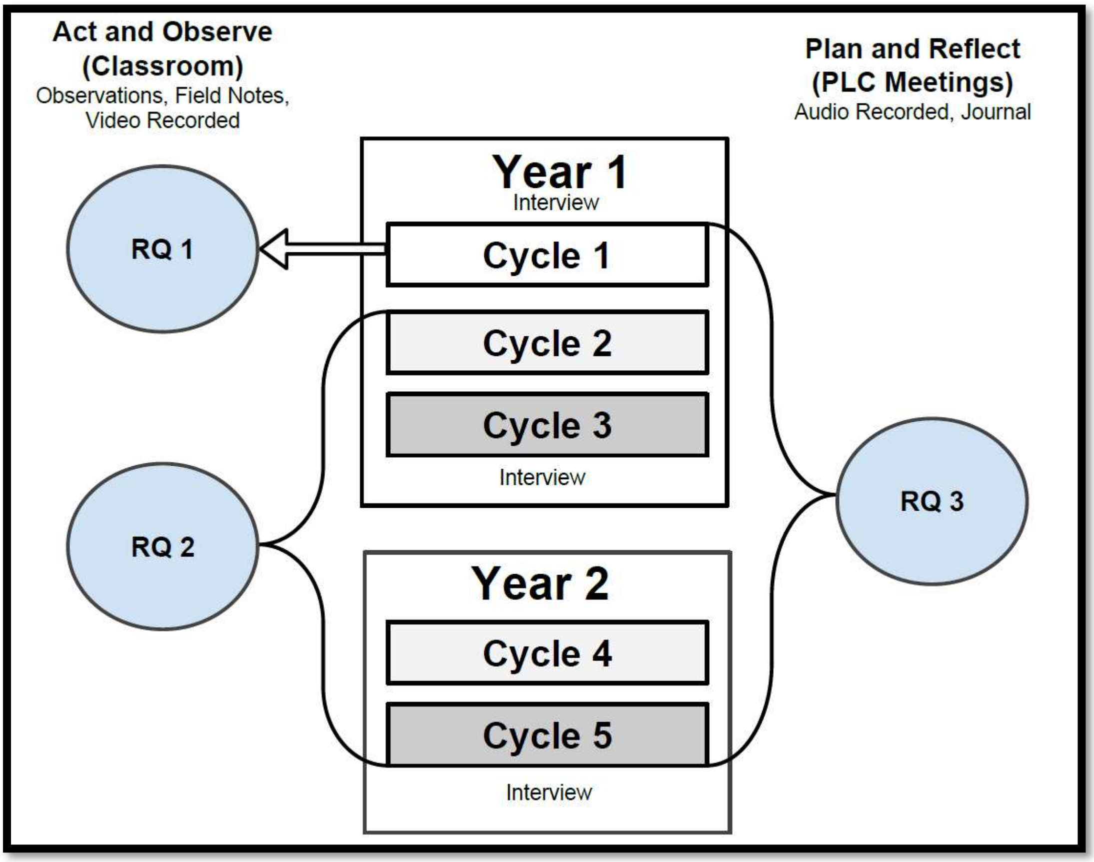


Figure 4 Linking the Action Research Cycles to my Research Questions.

Data collected at the start of my project (cycle 1) came from classroom observations, field notes and recordings of teachers' practices and this allowed me to answer research sub question one: in their baseline teaching practices how do teachers interact with LPK? (Cycle 1).

To answer my second research sub question: why do teachers interact with LPK the way they do, I used the same research methods to collect data in Cycles 2,3,4 and 5 as I did in Cycle 1 (classroom observations, field notes and classroom recordings) together with interview data collected before cycle 1, at the end of year 1 and at the end of year 2.

Audio recordings from reflect and plan PLC meetings of all cycles as well as responses from the semi structured interviews provided me with data to answer my third research question: What influence does attendance at successive PLC meetings focused on reflecting how teachers engage with LPK, have on teacher participation and their level of reflection? Before discussing the research, methods used to collect data, I will explain the context where my study was carried out and describe participants who agreed to be part of the study.

3.4 Context and Participants

3.4.1 Context

The school where data were collected is situated in a middle-class suburb south of Johannesburg, Gauteng. Most of the twelve hundred learners live in the area with a few commuting from outlying rural areas and townships. The school fees were R12 700 per annum at the time of data collection. The school does not offer a scholarship or bursary programme. Due to financial constraints some 15% of the learners were receiving a subsidy on their fees. Each learner is issued with his/her own textbook in all subjects taken. There is a functional library and five well stocked laboratories. Class sizes varied between 20 – 30 learners. Classes are mixed with respect to gender and race. English is the language of learning and teaching.

3.4.2 Participant Teachers

The study was conducted at the school where I was Head of the Sciences department. Informally and individually, I invited all grade 8 Natural Sciences (NS) teachers to participate in the research: Adele, Kate and Luke. The same teachers taught all grade 8NS classes in both years of the study. I taught one Grade 8 class in each year of the study. Except for myself, pseudonyms have been used. Since I worked within the interpretivist paradigm my sample consisted of a few participant teachers, allowing a context specific, detailed account of findings to be given (Creswell, 2012).

All participating teachers are English home language speakers and attended schools similar to the one they were teaching at, in that the schools were well resourced, class sizes less than 35 and teachers were well qualified. Participating teachers showed much variation with respect to their qualifications and number of years teaching experience (see Table 1).

3.4.2.1 Adele and Kate

Adele and Kate are both inexperienced teachers, who are Life Sciences specialist teachers. Adele completed a BSc majoring in Physiology and Psychology. Her education studies were completed during the PGCE one-year course following her three-year BSc. During this year

Adele majored in Life Sciences and Life Orientation[2]. Her highest qualification in terms of Physics is Gr 12 Physical Sciences. Adele had four years teaching experience at the start of the project.

Kate completed a four-year BEd majoring in Life Sciences and English. Kate's highest qualification in terms of the Physics is Gr 12 Physical Sciences. At the start of the project Kate had completed 3 years of teaching.

Kate and Adele both prefer teaching Life Sciences. However, due to a need of NS teachers, both had been allocated NS classes each year since they started teaching at the school.

Table 1 Teacher experience and Qualifications

Teacher	**Number of years teaching**	**Number of years teaching NS**	**Qualification**	**Major (s)**	**Physics Qualification**
Adele	4	4	BSc PGCE[3]	Physiology Psychology	Gr 12 Physical Sciences
Kate	3	3	BEd	Life Sciences	Gr 12 Physical Sciences
Luke	37	11	HDE[4]	Electrician work Maths, EGD[5]	Electrician Trade
Jenny	26	20	MSc	Botany Zoology	Physics 1

3.4.2.2 Luke

Luke is an experienced Electrical Technology teacher, who at the start of the study had 37 years teaching experience. Luke was asked to teach NS 11 years ago, when the school was short of NS teachers and Luke had space on his timetable to accommodate a class or two. Since then, Luke has taught NS only to grade 8s every year since.

3.4.2.3 Jenny

I was the Head of Department for Natural Sciences at our school (I have addressed potential ethical concerns this may have caused in section 3.5 Ethical Considerations p.63) at the time data were collected. At the start of the project I had been teaching for some 26 years. Whilst I am a Life Sciences specialist teacher, I too have taught NS to junior learners for 20 years.

[2] Life Orientation is similar to a Citizenship course.
[3] PGCE Post Graduate Certificate in Education
[4] HDE Higher Diploma in Education
[5] EGD: Engineering Graphics and Design, also known as Technical Drawing.

However, most of these years were spent teaching grade 9 learners and not grade 8. When choosing a topic to do my research, I wanted to make every endeavor to work as an equal with participant teachers. To this end I purposively did not want to work in the "Life and Living" strand of the NS curriculum, where my expertise lay. Fortunately, at the time of the research, learners were working in the "Energy and Change" (Physics) strand. By working with content where I was not recognized as an expert it was hoped that PLC meetings would be collaborative, and I would not be seen as an "expert teacher/researcher coming in with all the answers". I wanted to avoid a top down approach during reflect and plan meetings, as PLCs are less successful with this approach (Bolam et al., 2005).

3.4.3 Participant Learners

Learners mostly live in the surrounding suburbs of the school, with few commuting in from nearby townships. As my research focused on the grade eight learners it is necessary to explain how the school places Grade 8 learners in one of the nine classes. Learners are ranked according to their grade seven mathematics mark. The first 60 learners are placed in the first two classes. Thirty learners whose academic performance is not as strong as the first 60 learners, but where primary school teachers have identified learners as working diligently are placed in a third class. The remaining learners (some 190 learners) are randomly placed in the next 6 classes.

I used convenience sampling to select one grade 8 NS class from each teacher, each year of the study. Convenience sampling involves the researcher intentionally selecting participants to whom s/he has easy access (Cohen et al., 2011). A disadvantage of convenience sampling is that it is not possible for the researcher to say with confidence that the learners forming the sample are representative of the population they are part of (Creswell, 2012). The classes were selected based on the alignment of the classes' timetable and my ability to attend lessons. However, one of the top academic classes was purposively selected each year. Whilst it was hoped this class would be taught by a different teacher in the two years, this did not happen. In both years of the study, it was the academically strong class taught by Adele whose timetable aligned best to my ability to observe the class. Consequently, classes selected from Luke and Kate in both years of the study were academically weaker than Adele's class. The one grade 8 class I taught each year was also selected to formed part of the study. These classes too were not academically strong.

All learners in the selected classes were invited to participate in the research. This will be discussed further in the next section, 'Ethical considerations.' Some learners opted not to participate. The number of participants and non-participant learners for each class in each year is given in Table 2. In both years I had no non-participants, whereas few learners in Adele, Kate and Luke's classes did not participate. I discuss how I dealt with non-participant learners in the next section.

Table 2 Participating learners per class

	Year 1		**Year 2**	
	Participants	**Non Participants**	**Participants**	**Non Participants**
Adele	27	3	27	1
Kate	21	9	22	6
Luke	24	5	22	5
Jenny	28	0	29	0

Classes were mixed in terms of gender and were racially diverse (see Figure 5). Although the number of black learners in each class was considerably more. Many participant learners were bi or multilingual, with English, isiZulu and Sesotho being most spoken

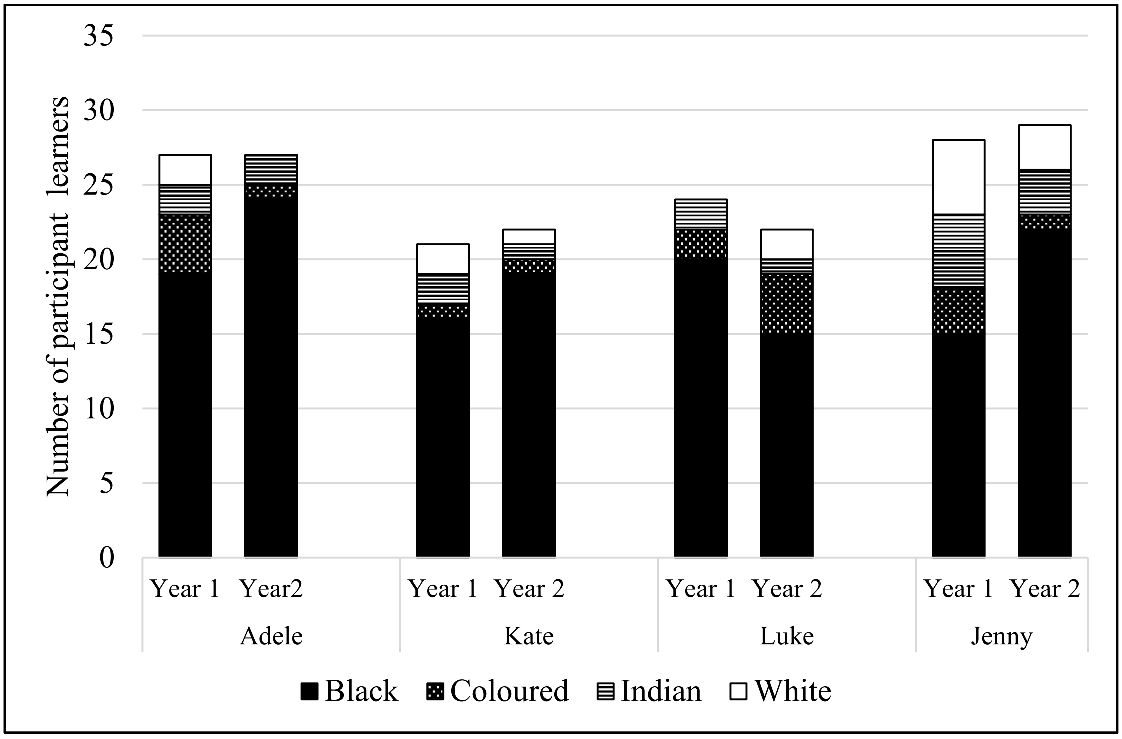


Figure 5 Racial Diversity of Participant Learners

3.5 Ethical Considerations

Due to its design, action research may result in a close relationship between teacher researchers, teachers and learners, which can lead to ethical issues(Creswell, 2012). Throughout the project I was mindful of the close association and paid careful attention to ethics, so as not to abuse my position at the school. Being Head of the Sciences department, I did not want participants to feel that I was exploiting the access I have to them.

At the start of the project four teachers (including myself) taught grade 8 NS. I spoke to each of the teachers individually informing them of the project and invited each teacher to participate in the project. Informed consent is an essential component of ethical behaviour as it respects the rights of individuals at the same time allows participants to make decisions for themselves (Cohen et al., 2011) . Informed consent includes: providing full information regarding the research to be undertaken, ensuring participation is voluntary, potential participants are able to comprehend what the project is about including what is expected of them and finally that potential participants are competent enough to make a well informed decision on whether they would like to participate or not (Cohen et al., 2011).

Teachers were made aware of the following aspects of the project: timeframes, purpose of the project, data to be collected and their part in the project. I explained the project in everyday terms such that it was easy to understand. It was crucial that participating teachers knew from the outset of the project the research I was undertaking was not a matter of research 'on' the teacher, rather research 'with' the teacher (Setati, 2005). To this end teachers were aware that the research was a collaboration. Together we would find solutions to problems we identified. As suggested by Cohen et al. (2011) I involved the participating teachers in as many phases of the research as possible, particularly when reflecting and planning lessons. All teachers were competent in that having been given information regarding the project they were able to decide whether they would like to participate or not. Letters inviting teachers to participate can be found in Appendix 1**.** All three teachers agreed to participate in the project.

Similarly, learners were informed of details of the project, data to be collected and how they would participate in the project. Learners were then invited to participate. Letters inviting learners to participate may be found in Appendix 2. As all learners were minors, letters were sent home to parents/guardians informing them of the project and inviting their child to participate. Parents needed to sign a letter giving permission for their child to participate in the project. Letters sent to parents can be found in Appendix 3. Informed consent needed to be given by both the learner and parents/guardians for a learner to participate in the project.

When inviting teachers and learners to participate I stressed participation was voluntary. I assured both teachers and learners they had the right to refuse participation in the project. Due to my close association with both teachers and learners I was explicit when stating that I was not pushing nor pressurizing them to participate. I explained that non-participants would not be affected in anyway. Likewise, participants were made aware they would not be rewarded. Participants were free to leave or enter the project at any stage. The project formed part of the normal teaching programme.

Non-participant learners were managed in the following way: during whole class teaching they were seated out of the field of view of the video camera. Any audio data that was recorded from non-participant learners was not transcribed. Non-participant learners were placed in the same group for group work activities, these groups were not recorded. No data from these learners has been included in the project at all.

Participants were also informed that all data collected would be used confidentially. This meant I would not disclose information from a participant that would allow the individual to be identified (Cohen et al., 2011). Further pseudonyms have been used throughout the project to ensure anonymity, so as to avoid potential harm and privacy invasion (Kemmis & McTaggart, 2005).

The Ethics Committee in The School of Education of the Faculty of Humanities at the University of the Witwatersrand granted ethics clearance for the project, Protocol Number 2015ECE007D (see Appendix 4). Permission to conduct the research was given by the Gauteng Department of Education for both years that data were collected (see Appendix 5 and Appendix 6). Having discussed the project with the principal of the school, permission was granted for the research to be conducted at the school, (Appendix 7).

3.6 Methods of Data Collection

Five cycles of the Action Research design have been completed, spanning two years. Data were collected using various methods in all phases of the action research cycles. To gain a deeper understanding of what was taking place teachers were interviewed three times during the study.

Data collection can be summarized into the following stages:

1. Interview teachers at the start of the project.
2. Cycle 1: Baseline Practices.
3. Cycle 2: Effects of Electric Current (EoEC) (Year 1)
4. Cycle 3: Light (Year 1)
5. Interview teachers end of year 1 data collection.
6. Cycle 4: EoEC (Year 2)
7. Cycle 5: Light (Year 2)
8. Interview teachers end of project data collection.

3.6.1 Interviews

Each teacher was interviewed three times during the project: at the start and end of year 1 and then at the end of year 2 (see Figure 4). As Cohen et al. (2011) write an interview allows the researcher access to "what is inside a person's head" (p. 411). I selected a semi-structured interview to interview teachers, as questions were asked that were open. Based on the teacher's response I probed their meaning further (Wengraf, 2002). Opie (2009) states that this approach encourages respondents to say what they think with a great degree of richness and spontaneity. Using semi-structured interviews allowed the direction of the interview to be guided by the teacher's responses and in this way the teacher was able to express ideas and thoughts I may not have considered (Opie, 2009). Semi-structured interviews provided teachers with an opportunity for their voice to be heard. I hoped teachers would express their thoughts and experiences of the research project during the interviews.

The purpose of the first interview was to discover what (if any) importance teachers place on working with learner prior knowledge in their current practices, as well as to find out the communicative approaches teachers prefer to use when (if at all) working with LPK. I have included the interview schedule as Appendix 8. Data from the first interviews provided insights into teachers' baseline practices.

The second and third interview with teachers took place at the end of the first and second year respectively. The purpose of these interviews was to explore teachers' experiences with the implementation of what had been discussed during 'reflect' and 'plan' meetings, as well as to get a sense of how teachers experienced the research process, particularly collaborating with peers. Interviews were conducted at the end of both years of the project as I hoped to gain deeper insights into teachers experiences over the course of the project. I was concerned if I interviewed teachers, only at the end of the project (year 2), teachers might describe their recent experiences and may exclude or forget how they experienced the first year of the project. I have included interview schedules 2 and 3 as Appendix 9 and Appendix 10 respectively.

I was not interviewed during the project. Since I had drawn up the interview schedule, I was aware of the questions I would ask the participants. Instead, I wrote reflection notes following my lessons. This allowed me to keep record of my thoughts as they happened throughout the project.

3.6.2 Observation and Field Notes

Observations are useful in research in that they provide researchers with a firsthand look at what is happening in a situation being investigated (Cohen et al., 2011; Denscombe, 2007). Further, observations allow the researchers to record information about both human behaviour and the physical environment. Finally data collected from observations can be used to check data collected by other means (Opie, 2009). However, observations may have the following limitations: first the Hawthorne effect, where participants alter their behaviour in response to their being aware they are being observed (Adair, 1984). Second, observations may be influenced by what Opie (2009) refers to as 'observer interpretation'. To avoid the later participants were given opportunities to read through data sets and reports generated from the project. Teachers were asked to comment on both interpretations and the claims being made.

I sat at the back of the classroom of all participant teachers for lessons that formed part of the research, where I made field notes. The reason for sitting at the back of classroom was I wanted to remain as unobtrusive as possible (Bloor & Wood, 2006). Field notes included information such as what was occurring in the class, seating arrangements, behaviors of teachers and learners as well as events happening at the school. For instance, some lessons of Cycle 3 occurred in the last week of term, many learners were absent for these lessons. In some lessons up to half the number of learners in a class did not attend school. Whilst making field notes, I also wrote down personal thoughts I had, as I reflected on events as they unfolded in the class as they applied to my broad themes: for instance, I was mindful of the interactions that occurred between the teacher and learner. Field notes were written for all but two lessons, which I was not able to attend. All lessons were both audio and video recorded.

3.6.3 Recordings

Audio recordings were made of lessons and interviews. A digital voice recorder was placed in the pocket of the teacher, just before learners arrived for their lesson. The digital voice recorder was placed on the table during interviews. Audio recordings allowed me to collect the actual utterances made during the lesson and interviews (Bloor & Wood, 2006). Advantages of using audio recordings include freeing the researcher from taking copious amounts of notes, allowing the researcher to focus on what is being said. Second, data collected is unbiased and not dependent on a researchers' selective attention, improving the reliability of the data collected.

Lessons were also video recorded. A camera was set up at the back of the classroom before learners arrived. Learners who did not want to be part of the research, were placed outside the field of view. The reason for using video recordings as well as audio recordings in lessons, was that I wanted to capture how participants responded to each other through the use of non-verbal behaviours, including facial gestures, body posture and use of artefacts (Bloor & Wood, 2006).

I was aware that participants may not behave as they would normally, knowing they are being recorded. Some participants may be reluctant to speak whilst others may behave in a way they believe is what the researcher is looking for (Bloor & Wood, 2006). The reluctance to behave as they normally would, may be caused by the presence of the recording device or the fear of loss of anonymity. By placing the digital voice recorder in the pocket of the teacher and having the camera set up at the back of the classroom it was hoped that the recording device would not be obtrusive, and participants might forget that they were being recorded. Participants were assured of their anonymity throughout the research project, from the time they were invited to participate, until the last of the data were collected.

3.7 Curriculum Content

The curriculum content selected forming part of the study was selected by the participant teachers. This was largely guided by the overlap between when data were to be collected and the content which was planned to be taught at that time. Two topics needed to be selected for the research. The research fell within the content 'Energy transfer in electrical system' and 'visible light'. The content area 'energy transfer in electrical systems' included various concepts ranging from circuits and current electricity, components of a circuit and effects of an electric current. Luke selected the topic 'effects of an electric current', as it was a small stand-alone section, which lent itself to working extensively with LPK (see Appendix 11). The second topic selected was 'visible light'. This was selected by mutual consent of all participant teachers as it aligned with the time data were to be collected. Only the first section 'radiation of visible light' was chosen from 'visible light' to form part of the research, as teachers felt that this was the start of a new section of work and provided many opportunities for teachers to work with LPK. Further, the remaining 'visible light' content was taught in the fourth school term. The Gauteng Department of Education (GDE) does not allow collection of data in the fourth school term. Appendix 12 provides an outline of curriculum content of 'radiation of visible light'.

3.8 Working with LPK

When planning lessons to work with LPK, the type of LPK as stated by Lin (2015) was considered: formal instruction, informal learning, everyday experiences, intuition, language, for the two content areas. No instances of science knowledge gained through religious nor cultural beliefs occurred in the teacher reflect and plan meetings, nor during lessons. Whilst it was possible to plan for LPK that has or should have been taught in previous grades as per the department curriculum, it is more difficult to plan for LPK that comes from other sources.

3.8.1 Formal Instruction

Planning for LPK gained from formal instruction did not mean teachers assumed learners had a meaningful understanding of concepts stated in the curriculum from previous grades. We accepted learners would have diverse understanding of concepts based on their various contexts when the topic was taught. For instance, learners were coming from several primary schools, it was likely that the way they were taught topics would vary. Further within a primary school it may happen that learners were taught by different teachers with different ways of explaining concepts. In addition, it may be possible that learners had forgotten concepts which had been taught or that a choice was made not to teach a topic.

It was decided the two subjects NS and Technology, from previous grades would be the most likely to have content that links to that of the project. The prescribed curriculum content was searched in the Curriculum, Assessment and Policy Statement (CAPS) documents (Department of Basic Education, 2011b, 2011c, 2011d)for the subjects NS and Technology, as both stated current electricity form part of the curriculum in various grades.

Learners in Grades 4-6 fall within the Intermediate phase and are taught NS and Technology as one subject(Department of Basic Education, 2011c). No reference is made to either content area in the Grade 4 curriculum. However, in Grade 5 in the strand 'Energy and Change' within the NS and in the Technology strand 'Systems and Control', learners are taught electricity for the first time: simple circuits, electricity comes from power stations and basic precautions that should be taken when using electricity.

The Grade 6 NS and Technology Curriculum prescribes the following be taught regarding electricity in the strand 'Energy and Change' and in the Technology strand 'Systems and

Control': Simple circuits and their diagrams, designing, making, evaluating, and presenting a system, that uses a circuit to produce movement, light, sound or heat in a structure such as a steady hand game, house, light house or a toy. The circuit should include components such as cell/s, light bulb/s, buzzer/s, and switch/es. It is suggested that this be done as a project. The remainder of the current electricity curriculum content is related to issues such as fossil fuels, renewable energy sources for generating electricity, cost of electricity and illegal connections.

In grade 7 learners are taught NS and Technology as separate subjects. The Technology CAPS curriculum states that the following content be taught in Term 3: 'Electrical Systems and Control' learners are to test various materials as to whether they are magnetic or not. Learners are also to build simple circuits with bulbs and buzzers and draw their circuit diagrams. Finally, the teacher is to demonstrate the building of an electromagnet, 'Make a simple electromagnet made by winding insulated copper wire around an iron nail. When electric current flows in the wire coil (solenoid) a magnetic field is created, and this is amplified by the iron core. Switching the current off causes the magnetic field to fade away'(Department of Basic Education, 2011d, p. 18). In Grade 8, learners are taught 'Electrical Systems and Control' in Term 4. The research project took place in Term 3 and Grade 8 learners would have been taught this content.

As part of the Grade 7 Natural Sciences curriculum the focus of the electricity content is on the national electricity supply system, how electricity is generated and how electricity is conserved.

Two brief references are made to 'light' in the Natural Sciences and Technology curriculum. First light is mentioned in the curriculum content 'Energy around us' where the CAPS document states 'we are aware of energy around us, including movement, heat, light, sound' (Department of Basic Education, 2011c, p. 23) . In the second instance light is referred to under the topic 'Our closest star': 'the Sun provides heat and light to the Earth for living things'(Department of Basic Education, 2011c, p. 27).

We planned for knowledge learners may have which came from outside the classroom: i.e. informal learning, everyday experiences and intuition. I will discuss how we planned for LPK from these sources in one group since, we were not interested in where learners may have gained the knowledge, merely that it may exist.

3.8.2 Informal Learning, Everyday Experiences, and Intuition

When planning lessons on EoEC we considered the following concepts which may form part of LPK: Uses of electricity in households. When considering the magnetic effect of an electric current we thought learners would be aware of magnetic materials and using a compass to detect magnetic. We thought learners would be aware that many light bulbs get hot when electricity passes through them, particularly the old tungsten type light bulb.

The following was considered as being part of LPK regarding the light content: how does light behave from a burning candle? How would light behave if the candle were lit in a light or dark room. We were aware of common alternative conceptions some learners have: light travels further in the dark, light occurs in space and not necessarily associated with a source, light leaves the eye and that is why we see.(Osborne, Black, Meadows, & Smith, 1993).We wanted to develop an activities to challenge these. We also thought learners were aware they had a shadow. However, we did not think they had really observed how their shadow behaves and so we developed activities for learners to explore their shadows in greater detail.

3.8.3 Language

When planning lessons, we did not consider possible words or concepts learners that may already be part of their vocabulary. Three instance of where a term is used differently in everyday language vs scientific language emerged in baseline lessons. All three instances were incidental and not planned. For instance, in my lesson I was concerned with discussing the term 'volume', as in how much volume does a liquid occupy. Whereas the learner responded in terms of 'sound', as in loudness of a sound.

I continue this chapter by explaining how teachers used both the curriculum and what they considered would be the knowledge learners would have when they entered class to develop lessons, reflect and revise aspects of the lesson that were considered less successful, as they planned the next lesson.

3.9 Practical Action Research Cycles

A total of five cycles were completed over the two years. I have included a summary of what happened in each cycle in the methodology chapter, as planning for each cycle was dependent on what had happened in, and reflections from the previous cycle. Cycles 1,2, and 3 took place in year 1 of the project. With cycles 3 and 4 taking place in year 2. Cycle 1 focused on teachers baseline practices. Cycles 2 and 4 were concerned with same content EoEC taught in successive years. Whereas cycles 3 and 5 took place in following years, focused on the topic light. Table 3 provides a summary of teacher reflections at the end of each cycle, and what was planned in the following cycle.

Table 4 provides detail of the number of lessons that formed part of the project, and time taken to complete the lessons. NS lessons are timetabled as either single 30-minute lessons, or as a double lesson with 2 single lessons taking place back-to-back, (60-minute lesson). All baseline lessons were double lessons (see

Table 4). Whilst teachers had planned the lessons of Cycle 2 together, Adele took 90 minutes to complete the work with her learners, whilst Luke, Kate and Jenny required an extra 30 minutes, with their lessons lasting 120 minutes.

Table 3 Summary of Action Research

<table>
<tr><th colspan="3"></th><th>Focus of Reflect and Plan Meeting</th></tr>
<tr><td rowspan="8">YEAR 1</td><td rowspan="2">Cycle 1 Baseline Practices</td><td>Act 1
Observe 1</td><td></td></tr>
<tr><td>Reflect 1</td><td>How, if at all do teachers work with LPK?</td></tr>
<tr><td rowspan="3">Cycle 2 Effects of Electric Current</td><td>Plan 2</td><td>Working with different sources of LPK.</td></tr>
<tr><td>Act 2
Observe 2</td><td></td></tr>
<tr><td>Reflect 2</td><td>Using various communicative approaches to work with LPK.</td></tr>
<tr><td rowspan="3">Cycle 3 Light</td><td>Plan3</td><td>Activities to work with LPK in various ways.</td></tr>
<tr><td>Act 3
Observe 3</td><td></td></tr>
<tr><td>Reflect 3</td><td>Activities lacking as learners struggled to make meaning.</td></tr>
<tr><td rowspan="6">YEAR 2</td><td rowspan="3">Cycle 4 Effects of Electric Current</td><td>Plan 4</td><td>Rework activities considering learner alternative conceptions.</td></tr>
<tr><td>Act 4
Observe 4</td><td></td></tr>
<tr><td>Reflect 4</td><td>Use of low order questions when working with LPK.</td></tr>
<tr><td rowspan="3">Cycle 5 Light</td><td>Plan 5</td><td>Types of questions to probe LPK.</td></tr>
<tr><td>Act 5
Observe 5</td><td></td></tr>
<tr><td>Reflect 5</td><td>Learner meaning and understanding.</td></tr>
</table>

However, the same cannot be said of Cycle 3. Both Kate and Luke completed the Light content in Year 1 in 3 lessons, whilst Adele and Jenny required an extra 2 lessons. During Cycle 4 the time taken to complete lessons varied between the teachers: here Luke and Jenny were done in

3 lessons (210 minutes), whilst Adele required one less lesson (180 minutes) and Kate needing 2 extra lessons (270 minutes) to get through the work and activities with here learners.

Table 4 Summary of Data Collected

Year 1					
				Number of Lessons	Time (minutes)
Cycle 1	Baseline Practice	Act 1 Observe 1	Adele	1	60
			Kate	1	60
			Luke	1	60
			Jenny	1	60
		Reflect 1	Adele, Kate, Luke, Jenny		60
Cycle 2	Effects of Electric Current	Plan 2	Adele, Kate, Luke, Jenny		60
		Act 2 Observe 2	Adele	2	90
			Kate	2	120
			Luke	2	120
			Jenny	2	120
		Reflect 2	Adele, Kate, Luke, Jenny		80
Cycle 3	Light	Plan 3	Adele, Kate, Luke, Jenny		75
		Act 3 Observe 3	Adele	5	300
			Kate	3	180
			Luke	3	180
			Jenny	5	270
		Reflect 3	Adele, Kate, Luke, Jenny		20
Year 2					
Cycle 4	Effects of Electric Current	Plan 4	Adele, Kate, Luke, Jenny		90
		Act 4 Observe 4	Adele	4	180
			Kate	6	270
			Luke	5	210
			Jenny	5	210
		Reflect 4	Adele, Kate, Luke, Jenny		35
Cycle 5	Light	Plan 5	Adele, Kate, Luke, Jenny		30
		Act 5 Observe 5	Adele	5	300
			Kate	7	300
			Luke	5	240
			Jenny	5	240
		Reflect 5	Adele, Kate, Luke, Jenny		20

Luke and Jenny required the least time to complete the work with learners in Cycle 5, requiring 240 minutes. Adele and Kate both took an extra 60 minutes, completing the work in 300 minutes.

The length of reflect and plan meetings is also given. Most reflect and plan meetings were around 60 minutes, with the shortest (Reflect 3) lasting 20 minutes and the longest (Plan 4) taking 90 minutes.

3.9.1 Cycle 1

The purpose of the first Cycle was to obtain data from teachers' baseline practices. I was seeking to answer my first research question: How do teachers interact with LPK in their baseline teaching practices?

The content of lessons that formed baseline practices was decided by the teachers. Teachers selected an hour lesson that I observed. I made field notes from the back of the class and recorded the lesson using both a video and audio recordings.

As reflections from one cycle inform the planning of the following cycle, I have provided short narratives of each reflect and plan meeting. The intention of these narratives is to provide the reader with an understanding of how one cycle informed the next. The narratives thus add to the richness of the data collected and provide a context to analysed data.

Reflect 1 How, if at all, do teachers work with LPK?

As the project was mine and teachers were initially shy to contribute during the meeting, I took the lead at the start of Reflect 1. I started the meeting by reminding teachers that the research project was concerned with exploring various ways to interact with LPK. I started the reflections by showing a small, recorded clip of how I had interacted with LPK. We discussed as a group what was going on. I found at least one instance where each teacher referred to LPK and we discussed whose 'voice' was being heard in the interactions? I suggested that the activities we design for learners to complete should give learners 'freedom to think'. Halfway through reflect 1 Luke suggested that we focus on the content EoEC in the next cycle.

It was agreed that this small section was ideal as it lent itself to working with LPK both from previous grades and content had been taught earlier in the year. Further the content allowed teachers to probe learners everyday understanding of the EoEC. Luke was also aware that many learners may have alternative conceptions on this topic and stated:

Turn 235 *You just say, 'Right what are the effects of an electric current?" And they will think, sound, light and, and that's wrong obviously.*

Luke

The remainder of reflect 1 focused on teachers throwing ideas back and forth. Much of the discussion was dependent on Luke explaining the content and suggesting possible activities. Towards the end of reflect 1 (Turn 319) I ask teachers to bring ideas to the planning session (plan 2).

Turn 319 *Ok, then we'll do that on Thursday. So, everybody must come with their big brain waves, on something.*

Jenny

Luke takes the lead and states that he will put some activities together.

Turn 322 *Oh that's excellent, I don't mind putting something together and then everybody just adds on to it. You can always add on to this.*

Luke

Plan 2 took place a week after reflect 1.

3.9.2 Cycle 2

3.9.2.1 Plan 2 Working with different sources of LPK.

Exactly a week following Reflect 1 teachers came together for a meeting lasting just short of an hour. Luke had planned and brought a worksheet to the meeting. I brought the CAPS document which detailed the content to be taught. Luke was thanked for his planning activities that could be used to explore LPK and teach the new content. Luke wanted to start by discussing current and magnetism. I reminded teachers the purpose of the project was to explore LPK and not jump straight into the content. We decided a good way to start the worksheet would be to ask learners to name various electrical appliances and state what effect of an electric current was allowing them to perform their function. This would allow teachers to explore learners' everyday knowledge. Soon into the discussion Luke was able to predict that it is likely learners will offer 'sound' as an EoEC.

Turn 96 *They are going to say sound effects, um light effects and that type of thing. It's not.*

Luke

For the following 120 turns there is a lot of back-and-forth discussion between the teachers and Luke., with teachers naming various household appliances and Luke stating which EoEC is causing the appliance to function. The discussion ends with Adele stating should a learner, suggest an appliance where she does not know which EoEC is applicable, she would send the learner to ask Luke. The rest of the PLC meeting was spent discussing the activities and resources needed to complete the activities. A decision was made to have a class competition, to see which group could build the strongest electromagnet, to move away from cookbook science and provide learners with an opportunity to work on their own.

Towards the end of the meeting, I offered to rework Luke's draft worksheet based on the comments and suggestions from the afternoon's discussion. I suggested passing it around for comment once I was done. Both Adele and Kate were unsure whether they would be able to make further comments.

Turn 544 *You don't have to pass it on to me.*

Adele

Turn 546 *I promise you when I see it, I am just going to say 'Ooh that's pretty and I am going to give it back.*

Kate

Luke assured the inexperienced teachers that they in fact have a most useful role to perform in looking over the work sheet. If the worksheet does not make sense to them, the teachers, it is likely the worksheet will not make sense to the learners. Plan 2 ended with a discussion on resources needed to complete the activities and how these will be distributed amongst the learners in a class and the teachers. The learner notes that were reworked can be found in Appendix 13 .

3.9.2.2 Reflect 2 Using various communicative approaches to work with LPK

Reflect 2 was a meeting that lasted almost 80 minutes, with 979 turns being coded. Luke started the discussion with concern of the sharing of resources between teachers. This is followed by a discussion on learners' lack of understanding, with a suggestion that learners use their textbooks as a resource to help them make meaning of concepts.

When probing LPK, learners need time to think about what they know (or don't know). Kate suggested one way to give learners more time to think about what they know is to provide them with questions which they take home and complete as an individual activity. Once the learners have done the activity teachers can work through the answers with the learners.

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A debate arose on frustrations involved when teachers give learners an opportunity for their voice to be heard. Kate raised a concern that probing LPK was time consuming, as teachers needed to provide learners with enough time to think about what they already know. It was decided that some activities learners would be asked to complete as homework. A second concern raised by Luke, was that many learners had forgotten content that they had been taught in previous grades. There was consensus amongst teachers that learners struggled to follow instructions, which meant learners did not complete activities as required. It was suggested a larger font be used for instructions to activities.

The second half of the meeting focused on what content to teach for Cycle 3. The content 'visible light' was agreed upon. Luke was upfront about his perceived lack of content knowledge in this content area:

Turn 397 *But here I fall apart.*

Luke

I suggested using both everyday language and using diagrams to probe LPK. Activities such as asking learners to draw what they think happens to the light when a candle burns or to draw how their shadow forms were suggested. Learner would complete activities exploring LPK by explaining their meaning in words and diagrams.

Luke ended the meeting by raising concerns of disruptive learners who do not bring stationery, or books to school. The same learners tended to go off task during group work activities. Dealing with these learners was not only time consuming, but also frustrating.

3.9.3 Cycle 3

3.9.3.1 Plan 3 Activities to work with LPK in various ways.

Plan 3 took place a week following Reflect 2. The meeting lasted 1 hour and 15 minutes, with 1371 turns being transcribed. I was the only teacher to bring any form of preparation. Having read literature on common alternative conceptions learners may have with respect to understanding 'visible light' and based on the discussion from reflect 3, I drew up a worksheet which formed the basis of the discussion of plan 3.

The proposed activities were discussed and changed to include more diagrams to probe LPK and challenge possible alternative conceptions (see Appendix 14). As an example, some learners' understanding is that light leaves the eyes to what is being seen(Osborne et al., 1993). An activity was given where a boy is reading using light from a lamp, and learners were asked to indicate how they think light moves. Teachers agreed the activities may provide teachers with insights into how learners make meaning of concepts.

Some activities were focused on probing learners' understanding of everyday phenomena they were possibly aware of but may not necessarily have thought why it happens: for instance, how light from a burning candle behaves, what causes shadows and how light moves allowing one to read.

Teachers spent the second half of plan 3 constructing pinhole cameras learners were required to make. Discussions on improving the construction of the camera occurred with some teachers suggesting using black paper instead of white and strengthening the camera by using cardboard. The meeting ended with teachers discussing logistics of the project: i.e. aligning their teaching to my availability to observe and record lessons.

3.9.3.2 Reflect 3 Activities lacking as learners struggle to make meaning.

Reflect 3 took place 3 weeks after the plan 3 meeting. Whilst the meeting only lasted for some 20 minutes, 307 turns were transcribed. Many teacher reflections were focused how learners interpreted completing the activities. Teachers then reworked the activities in the hope of improving learner understanding. For instance, learners were asked to draw how they think light behaves when a candle burns. Luke was frustrated by the diagrams his learners drew.

Turn 14 *I found that when they drew the candle, they wanted to colour everything in, because they didn't do it scientifically.*

Turn 16 *They knew what, they knew what light was going to be. But they didn't know how to show it, light rays and that.*

Luke

It was Kate who suggested to change the wording of the instruction, instead of asking learners to 'draw a diagram' this be changed to 'draw a picture' That way learners will not be restricted by the various rules of scientific drawings taught earlier in the year.

3.9.4 Cycle 4

Cycle 4 was the first cycle in the second year and focused on the content EoEC. Plan 4 was a meeting lasting 90 minutes.

3.9.4.1 Plan 4 Rework activities considering learner alternative conceptions.

The amount of time each plan and reflect meeting was not prescribed, although it was hoped to keep meetings around an hour. Plan 4 lasted 90 minutes with 1136 turns being transcribed from the audio recording. The meeting was lively with much back-and-forth discussion occurring between the teachers. Whilst many issues and concerns were raised, the focus of the meeting was to address parts of the lesson sequence where learner misconceptions were evident, so as to improve learner meaning making.

Teachers identified three areas where reworking of activities was necessary: First, whilst learners were busy with activities to explore various EoEC, it seemed that learners were so focused on completing the activities they were unaware of the effect of electricity being investigated. This was evident as learners were unable to state the three effects of electric current once the content had been taught. Second, learners considered both sound and light an EoEC. Third, learners struggled to associate the deflection of a compass needle with a magnetic field. Finally, many learners did not link the current moving through the copper wire as causing a magnetic effect.

In the following extract taken from the plan 4 teachers discussed how to phrase questions to guide learners, in their understanding, that copper is a nonmagnetic material.

Turn 900 *Is copper wire, or copper metal magnetic?*

Jenny

Turn 901 *Explain your answer?*

Adele

Turn 902 *Explain your answer. Ja, then they've got to write more than a sentence.*

Jenny

Turn 903 *Give a reason.*

Luke

There is a lengthy back and forth discussion between the teachers about how to phrase questions to provide some scaffolding allowing learners to understand copper is a nonmagnetic material, yet when it is used as a conductor in a closed circuit, a magnetic field exists around the wire. Luke phrases the following question in turn 933

Turn 933 *Because you have seen that copper is not magnetic, So, how is it possible that copper is not magnetic, but it can cause the compass needle to deflect?*

Luke

The focus of plan 4 was on reworking the activities, particularly how activities were ordered, thereby emphasizing the three EoEC. Attention was given to the phrasing and sequencing of questions. Teachers discussed how to improve diagrams. It was also decided to include a mind map at the end of the worksheet that would provide learners with an opportunity to consolidate the three EoEC. The lesson plan and the revised learner notes can be found in **Appendix 15** and Appendix 16.

3.9.4.2 Reflect 4 Use of low order questions when working with LPK.

A total of 413 turns were transcribed during reflect 4 where teachers reflected on teaching and learning of the topic EoEC. Teachers' reflections included acknowledgment of an improvement in learner understanding on three EoEC. This was attributed to the revised sequencing of activities and the mind map. A second improvement was the availability of resources. Resources were not shared in year 2, which meant teachers did not need to worry about planning lessons around the availability of resources.

Teachers spent some time reflecting on learner alternative conceptions. For instance, it emerged in two lessons that some learners perceive electrodes as magnets. Reasons for this may be that the electrodes used in the electrolysis experiment, looked like magnets and the diagram showed the electrodes having a charge.

Teachers spent time reflecting on the effectiveness of group work. Teachers were concerned that group work discussions were shallow, and learners did not interrogate the content much.

Turn 44 *I didn't think their discussions were very in depth. I don't think they know how to discuss this. Like they don't go further than what's written on their prac.*

Kate

Three times during reflect 4 I suggest to teachers a possible solution to this problem is to consider the types of questions we ask the learners.

Turn 53 *And maybe that is what we should explore, instead of going too much into the nitty gritty of each of these. Is the questions we ask. Because I wrote here (referring to notes on lesson plan), the group work did not generate much discussion. And most of what I am doing is procedural. And maybe what we need to do here is to think of questions we can ask. Generic questions to probe understanding and move away from procedure.*

Jenny

Towards the end of reflect 4 teachers considered the types of questions they could ask learners that would encourage learners to explain their meaning more fully.

Turn 290 *Ok, so the magnetic effect, ok. So, what equipment are you using? Why are you using this equipment?*

Luke

Turn 294 *What does it prove?*

Adele

Turn 303 *What information are you going to need? Why?*

Luke

3.9.5 Cycle 5

The final cycle was concerned with the content light and was taught in the second year.

3.9.5.1 Plan 5 Types of questions to probe LPK

Plan 5 took place directly after reflect 4. The discussion lasted just over half an hour with 455 turns being transcribed. Teachers were aware that they were going to plan for the light section of work, yet I was the only teacher who came prepared with resources, e.g., learner notes from the previous year and ideas on how to better construct a pinhole camera.

Various topics were discussed throughout the meeting, including the idea that LPK does not only occur at the start of a lesson and in-depth discussions on how to change activities to improve learner understanding.

A lengthy back and forth discussion occurred (turns 41- 89) where teachers debated on questions to ask that would provide teachers with better insights on learners' understanding as to how light behaves when a lit candle is placed in a dark and light room. Many learners had shaded the area around the candle, much like a halo, indicating how light behaves. Learners struggled to explain how light from a candle burning in a light room, differed from a light coming from the same candle burning in a dark room. Teachers decided to ask learners to draw two pictures: one of a candle burning in a lit room and one of the same candle burning in a dark room. Learners were asked to use arrows to show the behaviour of light in both diagrams. Kate suggested learners should also be afforded the opportunity to explain their meaning, as this is how they would be assessed in their exams.

Turn 85 *I think we should actually have them put it in words. Cause more often than not, when, well all the time they have to write an exam. But can they explain it?*

Kate

Adele suggested the activity require learners to both draw and explain their meaning.

Turn 89 *Why don't they draw both and explain?*

Adele

When teachers reflected on the 'shadow activity, where learners we required to draw their shadows, it was agreed that learner understanding was poor. After much debate (turns 203-229) teachers recognized that learners' attention needed to be drawn to: the position of the sun, object, and shadow. The lesson plan and revised learner notes can be found in Appendix 17 and Appendix 18**.**

3.9.5.2 Reflect 5 Learner meaning and understanding.

Reflect 5 was a short meeting lasting 20 minutes, with 346 turns being transcribed. Much of the time was spent on teachers reflecting on the 'shadow activity'. Having discussed the activity at length in plan 5, teachers were mindful of the errors that still occurred.

Turn 111 *I think this whole activity needs to change, because my children still didn't get it.*

Jenny

Luke struggled to understand why learners battled with the activity. He was of the opinion that, by the time learners get to primary school, they should have some idea of the position of their shadow.

Turn 129 *This is stuff we should know by the time you even get to school, primary school, grade 1. 'Look I've got a shadow. Is it following me or leading me?*

Luke

Adele suggested perhaps having learners do the activity individually might focus their observations better.

Turn 140 *They don't work in groups. They don't work together. They have got to work by themselves, Right. And they've got to stand somewhere. And they've got to figure out, where's the sun and where's the shadows.*

Adele

A second concern teachers raised was that learners did not complete activities requiring explanations. Some of the discussion was concerned with possibly allocating marks for answers. It was thought learners might be more motivated to complete the work, thinking it would form part of the formal assessment programme. However, Luke suggested a reason for learners' inability to write in sentences was their poor vocabulary. Luke proposed that learners be provided with a list of key words, that would assist them in writing their answers.

3.10 Data Analysis

The analytical frameworks were chosen with the purpose of coding transcribed data from both classroom lessons and PLC meetings, that would allow me to answer my research questions and sub questions. The analytical frameworks I have separated into two groups: first, those that focused on the identifying the types of interactions and communicative approaches used in a lesson and second frameworks that focused on the teacher's reflective practice when teachers participate in a PLC.

3.10.1 Analyzing meaning making interactions

The primary analytical framework guiding analysis of the classroom transcripts comes from Mortimer and Scott's (2003) work described in their book "Meaning making in secondary science classrooms": Analyzing meaning making interactions in science classrooms. Using this framework, I was able to analyze data collected from lessons so that I could answer my first and second sub-research question. My first sub research question asked: how do teachers interact with LPK in their baseline lessons? My second sub-research question was Why do teachers interact with LPK in the ways that they do?

Mortimer and Scott's framework draws on a sociocultural perspective on teaching and learning and was useful for this study as it incorporates both LPK, various communicative approaches teachers use when teaching and considers the patterns of interactions that occur in a classroom. The framework is divided into three aspects: focus of the lesson, approach taken in the class and the actions of the teacher in the class (see Table 5).

Table 5 A tool for Analysing Meaning Making Interactions in Science Classrooms (Mortimer & Scott, 2003)

Aspect of Analysis			
(i) Focus	1. Teaching purpose		2. Content
(ii) Approach		3. Communicative Approach	
(iii) Action	4. Teacher interventions		5. Patterns of interaction

The two aspects within this framework that were useful in analyzing data were: communicative approach and patterns of interaction.

3.10.1.1 Communicative approaches

Mortimer and Scott (2003) described their communicative approaches across two dimensions: First, discourses may be defined as being authoritative or dialogic. An authoritative communicative approach occurs where only one voice is heard, usually the teachers. In a dialogic communicative approach, the discourse is open to various people's points of view. A dialogic discourse may take on different forms, depending on when it occurs in the lesson sequence. For instance, a dialogic discourse at the start of a lesson sequence when the teacher is eliciting learners' prior knowledge would be different from dialogic discourse that occurs towards the end of the lesson sequence, where learners work on activities, where learners are required to apply their recently gained school science knowledge to answers problems.

The second dimension to consider when considering types of communicative approaches is to consider whether teaching episodes are interactive or not. A teaching episode is considered interactive when there is participation by other people, whereas a non-interactive episode only involves one person, usually the teacher. Essentially, communicative approaches consider how many people are interacting in the discourse and how many voices are being heard?

Combining the two dimensions, Mortimer and Scott (2003) classified four types of communicative approaches, (see Table 6).

Table 6 Four Classes of Communicative Approaches

	Interactive	**Noninteractive**
Dialogic	A. Interactive/Dialogic	B, Noninteractive/ dialogic
Authoritative	B. Interactive/Authoritative	C. Noninteractive/Authoritative

The four communicative approaches:

A. Interactive/Dialogic: here a range of ideas are expressed. The classroom activities are worked out allowing learners to ask questions, explain and debate as they work with various points of view. An interactive dialogic approach occurs when learners work in small groups discussing ideas. Teachers do need to support learners.

B. Noninteractive/Dialogic: in this type of approach a person (the teacher) summarizes or lists various points of view, the same person may even look at similarities and differences between the various contributions. There is no interaction with the learners.

C. Interactive/Authoritative: here the teacher is concerned with only one point of view. The teaching episode is focused on establishing and consolidating that point of view. To do so the teacher may guide learners through a series of questions and answers, all the time knowing where the end point of the teaching episode is.
D. Noninteractive/Authoritative: a lecture type teaching episode would be an example of such a communicative approach. One voice is heard, and there is no interaction with learners. (Mortimer & Scott, 2003)

I turn my discussion on how I analysed my data to consider the 'patterns of interaction' taking place in classroom discourse. Understanding the 'pattern of interaction' helps in coding the type of communicative approach.

3.10.1.2 Patterns of interaction

A common type of teacher: learner interaction occurring in high schools is the 'IRE' interaction (Smart & Marshall, 2013). In these triadic exchanges, teachers start the interaction usually in the form of a question I (initiation). A learner would respond (R). The interaction comes to end when the teacher evaluates (E) the response (Lemke, 1990). This type of interaction does not allow for various ideas to be discussed in depth at all, as the teacher is usually looking for 'correct' answers and then moves on (Mortimer & Scott, 2003; Smart & Marshall, 2013). This type of interaction is characteristic of an authoritative communicative approach (Mortimer & Scott, 2003).

A second type of interaction occurs when instead of the teacher making an evaluation of the learner's response the teacher feeds back the response either to the same or another learner in the class. The interaction would take the form of IRPRE (where P stands for prompt), (Scott et al., 2006). The prompts teachers use could be asking a learner to elaborate on what they mean, or to provide an example. The 'correctness' of an answer is not relevant. The teacher's questioning is flexible, as the teacher adjusts his/her questions based on the learner's response in order to engage the learner in higher-order thinking (Chin, 2006; Smart & Marshall, 2013). This type of interaction supports a dialogic communicative approach(Mortimer & Scott, 2003).

When coding data I distinguished between IRE and IRPRE episodes. Given below is an extract from Kate's second lesson in Cycle 4 to illustrate an IRPRE episode.

Turn 246	Kate	*Ok, and then number 4, which effect of an electric current caused the copper chloride to split into copper and chlorine? Mpho?*	I
Turn 247	Mpho	*Ma'am, I said magnetic.*	R
Turn 248	Kate	*Ooo, was it the magnetic effect? Why do you say magnetic effect? What, what made you say that.?*	P
Turn 249	Mpho	*Because the copper was attracted to the um, the. the cathode. Ma'am so.*	R
Turn 250	Kate	*So, because you were seeing positive and negative you thought it was magnetic?*	P
Turn 251	Mpho	*Yes, Ma'am.*	R
Turn 252	Kate	*But remember we are talking about a chemical substance here. Ok, all right. But that's a chemical process. Mpho.*	E

Kate Year 2 Cycle 4 Second Lesson

Any move that involved a prompt to the same learner or a toss back to another learner was coded IRPRE, regardless of the number of tosses or prompts. Not all interactions were as straightforward as the IRE and IRPRE. Sometimes a teachers' evaluative 'E' response was not always explicit. On some occasions, teachers would repeat a learner's response, usually the implicit meaning being understood by learners, as the teacher both acknowledged and confirmed what the learner had said. The transcript below is of one such episode that occurred in Adele's baseline lesson:

Turn 73	Adele	*Beryllium. What's that symbol again?*	I
Turn 74	Chorus:	*B e*	R
Turn 75	Adele	*So, glad you guys remembered. ...*	E

Adele Baseline Lesson

Some interactions were 'dyadic', in that they were coded 'IR' where a teacher would ask a question. A learner would respond with the correct answer, which the teacher did not evaluate. Instead, the teacher would move the lesson forward in the way it was planned. Such an instance occurred in Kate's baseline lesson (see transcript below).

Turn 119	Kate	*And, what's the volume?*	I
Turn 120	Chorus	*10m.*	R
Turn 121	Kate	*Who can work out the density, for me quickly?*	I

Kate Year 1 Baseline Lesson

The last type of pattern interaction coded from classroom discourse was: 'IRRE'. Here a teacher would allow learners to provide answers one after the other, without probing or evaluating learners' responses. An example of one such episode occurred in Year 1 of Luke's baseline lesson.

Turn 368	Luke	*Can you see the little red thing there? Ok, you press the button. Where would you find something like that?*	I
Turn 369	Phindi	*At a theme show.*	R
Turn 370	Philip	*A remote.*	R
Turn 371	Trevor	*In a factory*	R
Turn 372	Luke	*No, you can't just say a factory. I, find, um, machines in a, a factory.*	E

Luke Year 1 Baseline Lesson

Learner utterances, the "R" in IRE or in IRPRE patterns of interaction were coded using the coding scheme described by Pimentel and Mc Neill (2013). This coding scheme was useful in that learner responses could be coded based on their completeness which is linked the level of thinking by the learner. The more complete a learner response, the more learners have tapped into higher order thinking and by their response were making explicit their understanding of concepts. A response was coded 3 when it was a complete sentence including a reason for the statement. A response was coded level 2 if it was. a complete sentence. A code level 1 response was one that was a word or phrase, whilst code 0 responses were utterances that involved no thought, nor did they add to the discussion. A few responses could not be coded as they were inaudible. Table 7 provides examples of learner responses to illustrate each code.

Table 7 Coding Scheme for Learner Contributions

Code	**Category Name**	**Learner Example**
0	No thought	"Ma'am." / "I don't know."
1	Word/phrase	"Electrons."
2	Complete thought	"The atoms have positive and negative charges."
3	Thought and reasoning	"The flow of electrons causes friction, and the friction causes heat."

Responses of teachers to learner responses determine the pattern of discourse, either supporting or discouraging further learner contributions. I used the four categories of teachers moves as defined by Pimentel and Mc Neill (2013) to code the discourse in each lesson: cut off, probe, toss back and elaboration, (see Table 8). However, I added two categories 'evaluate', and 'ignore'. A teacher move was coded as 'evaluate' when a learner response was assessed as being correct or incorrect. I have added this category since this teacher move was used frequently by all teachers.

In some instances, teachers ignored a learner response. This may have been that either the teacher did not hear the response or that the teacher intentionally ignored the learner contribution as it was made by learner who was seeking attention by making a statement which was irrelevant to the content being discussed. Luke had a learner, Trevor, who throughout the lesson demanded attention, often shouting out answers even though the learner was aware this behaviour was not acceptable.

Turn 173	Luke	*A negative charge right, because electrons are negative*
Turn 174	Trevor	*Sir, what happens if it is going to explode like the Hiroshima nuc?*
Turn 175	Luke	*What I would like you to do is not shout. Ok, let's pretend that we are in a normal class and we are not going shout out, we're just going to put our hands up. I can see you guys. I can see everybody. Trust me on that one. Coming back to static electricity. A remote.*

Luke Year 1 Baseline Lesson

In this instance Luke ignored Trevor's response, opting to remind him of the behaviour that is acceptable.

Table 8 Coding Scheme for Teacher moves

Code	Description	Example
Cut Off	Learner is unable to finish a response.	Teacher: Does my balloon have enough electrons? Boale: Hmm, yes Ma'am… Teacher: It does have enough electrons.
Probe	Learner is asked to clarify what they mean.	Teacher: You've seen a charge? What does it look like? Thabo: It looks like electricity? Teacher: You've seen electricity? What does it look like? Thabo: It's blue.
Toss Back	A learner is asked to comment on another learner's utterance.	Kamo: Ma'am, they have less people in, than we do. In this row it's three per row like here. Teacher: Ok, she's not exactly correct. John can you tell me why?

		John: Ma'am the other rows are bigger and there's more people in them. Teacher: There we go.
Elaboration	The teacher elaborates on a learner's response.	Teacher: And what is the rubbing called? Yes, Queen? Queen: Friction. Teacher: Friction. Ok. So, anybody's hands cold. My hands are cold right? So what you're going to do for me. Take your hands and you're gonna rub them together. What's happening?
Evaluation	The teacher evaluates a learner response, with no further discussion.	Teacher: Charging your phone. It puts energy back into the, the cell phone battery, hey? It charges the battery. What effect do we use? Learner: Electrical. Teacher: Chemical effect. There is no such thing as an electrical effect.

I turn my discussion to consider the analytical framework I used to analyse teachers' reflective practice.

3.10.2 Analytic Framework: Teachers' Reflective Practice

The second part of the study was concerned with teachers' reflective practice; my third research sub-question asked: what influence attendance at successive PLC meetings focusses on reflecting how teachers engage with LPK, have on teacher participation and the level of reflection. I have used the various levels described by Zeichner and Liston (1987) and O'Sullivan (2002), to code teachers' reflective practice. Zeichner and Liston (1987) distinguish between three increasing levels of reflection: technician, craftsperson, and moral craftsperson. Teachers reflect at a technician level when their focus is on completing that which has been decided by others, for instance curriculum completion. A craftsperson reflective teacher is one who considers educational reasons for their classroom actions. They contemplate whether educational goals are being achieved and how well. A moral craftsperson reflective teacher contemplates the moral and ethical implications of actions within a context. Zeichner and Liston developed their three levels of teacher reflection from their US study of primary school pre-service teachers. However, in her study working with Namibian teachers, O'Sullivan (2002) argued transferring western reflective learning was not always possible in developing country contexts. Whilst Namibian teachers were able to identify problems with their practices, they were unable to suggest solutions to areas of concern. The Namibian teachers were reflecting at a level lower than Zeichner and Liston's technician level. O'Sullivan coined the term 'basic technical awareness' to describe the low level of teacher reflection. I have referred to teacher reflections at the 'basic technical awareness' level as 'basic technician' reflective teachers.

3.11 Validity

Validity refers to ensuring that the data which has been collected is an accurate gauge on what the researcher is trying to measure (Opie, 2009). Using various strategies such as triangulation and member checking, qualitative researchers are able to better determine the credibility and accuracy of their findings (Cohen et al., 2011). Both triangulation and member checking were used in my study. I start my discussion on validity by first discussing how triangulation is used to enhance the validity of a study and then explain how the various sources of data were used to compare results. This is followed by a description on 'strategies ensuring validity in action research' Mills (2011). I will discuss member checking in the latter description.

3.11.1 Triangulation

Cohen et al. (2011) list six types of triangulation including: time, space, combined levels of triangulation, theoretical, investigator and methodological triangulation. They warn that studies that collect data at a point in time, may ignore any effects of social change. Researchers use time triangulation in longitudinal studies where data are collected from the same sample at different times. Space triangulation is concerned with including data from many cultures and people from different places in a study. A third type of triangulation considers data from various unit of analyses. For instance, data collected and analyzed from an individual, group and organization are compared. Theoretical triangulation involves applying alternative theories to a perspective. When several observers are used in data collection, investigator triangulation has been utilized. Methodological triangulation could be used in one of two ways: 'within methods' and 'between methods. 'Within methods' triangulation involves repeating a study, whereas 'between methods' triangulation requires more than one method is used to collect data. I have used 'between methods' triangulation to increase the trustworthiness of findings, where I have gathered and compared data using recordings, observations, and semi-structured interviews. Observations of some of my lessons were made by participants viewing recordings of my lessons during PLC meetings. Sources of my reflections were from reflection notes and discussions in the PLC meetings as participants discussed various issues.

Whilst the goal of triangulation is the notion of convergence: i.e. data collected using various methods, or from different sources, or data collected at different times and or in different spaces, is consistent and agrees (Cohen et al., 2011). Mathison (1988) argues what frequently occurs is an inconsistency amongst the data. What may result by collecting data from different sources, or using various methods, is that alternative perceptions and ambiguities become evident. Further, it may happen that contradictions in the data occurs. Mathison argues, that this is where the true value in triangulation lies: presenting evidence that is convergent, inconsistent, and contradictory. It is the researcher who needs to construct explanations about the data. I have attempted to be candid about findings that emerge from various data sources, even if these contradict each other. For instance, in their interviews some teachers claimed they refer to academic journals to gain insights into alternative conceptions learners may have. However, there was no reference to any academic readings in the reflect and plan meetings. Teachers mostly drew on their experience.

3.11.2 Strategies for Ensuring the Validity of Action Research

Mills (2011) addresses 8 strategies pertaining to validity that should be considered for an action research design. First, the teacher researcher should: listen more and talk less, particularly when conducting interviews and in discussions. I chose a semi-structured interview protocol in the hope that by asking open questions and then probing teachers thinking I would talk less. Further, teachers were provided with open ended questionnaires to guide their classroom reflections in year 1 and were also encouraged to reflect on their lesson plans. In this way it was hoped teachers would be provided with opportunities for their voice to he heard.

Second, researcher should record observations accurately. Whilst conducting research audio and video recordings may be taken, Mills suggests writing field notes after lessons, to accurately capture the essence of what. In my study every lesson forming part of the study was recorded (audio and video). In all but two lessons, I sat at the back of the classroom and made field notes where I noted both what was happening and looked specifically for instances of teachers working with LPK, and how the teacher integrated this into her/his lesson. I also noted any observations I found interesting: for instance, lessons were recorded in the last week of term in Year 1, after the term assessments had been completed. The number of learners absent from school was concerning. None of the participants were observers in my lessons. However, during PLC meetings recordings of the lessons (including mine) were shown and reflected on.

Third, writing reflections early before they become a distant memory and more likely become a ‘romanticized’ version of what took place in a classroom. Within 24 hours of the lesson being observed I wrote reflection notes. I wrote reflections notes following all reflect and plan meetings.

Four, share data with participants. Mills recommends sharing results with teachers as they become available, in this way there may be better buy-in to the next action research cycle. Sharing results with participants also ensures the accuracy of the findings, in what Cohen et al. (2011) refer to as member checking. Findings may be presented to participants in various ways: an interview, meeting or a written report. In all instances, participants are provided with an opportunity to give feedback on their interpretations of the data; is it without bias and true, are themes accurate and has a complete description of the study been given (Cohen et al., 2011). Regarding reporting of data to participants: teachers were presented with findings as they emerged. From years 3 to 6 of the study, a presentation was made at the South African Association for Research in Mathematics, Science and Technology Education's (SAARMSTE) annual conference. These presentations were also made to the participating teachers. Teachers were encouraged to make comments and suggest changes.

Fifth, report data fully, even data that is contradictory. Mills suggests the researcher seeks explanations to understand what is happening in the classroom. Data which is been found to be contradictory to what has previously been reported, should also be reported. Sixth, the teacher researcher should be truthful about their work, and be explicit about any biases they may have about the study. Throughout the project I was aware of biases I may have and have made these explicit.

Seventh, get feedback from colleagues, on the study. In this way questions may be raised regarding the accuracy of what is being reported. Finally, having written the report have it checked by a colleague, to check for contradictions in text. Regarding receiving feedback on the study: I have made several presentations and written many reports on findings of the study as they emerged. These included 5 written reports to various readers for the Wits School of Education, Research Degrees weekend. I have attended three research schools, organized by SAARMSTE, where a mentor was assigned to read my work and suggest revisions. Abstracts for the snapshot and three short paper presentations for the SAARMSTE conferences (2016-2019) have been read and the papers accepted. I presented a poster at the European Science Education Research Association biannual conference ESERA in 2017. Finally, a paper has been published in the African Journal of Research in Mathematics, Science and Technology Education (AJRMSTE), (Woolway, Msimanga, & Lelliott, 2019), where three reviewers suggested changes to article. Having many and varied educational researchers read and review my work it was hoped that interpretations of data were an accurate account of what happened.

3.12 Conclusion

An interpretivist paradigm was used to conduct the qualitative research in a high school in the suburbs of Johannesburg. Four Grade 8 Natural Sciences teachers and one class from each teacher were participants. A practical action research, research design was used to collect data, with 5 cycles being completed, over two years. In Cycle 1, teachers baseline practices were observed and reflected upon. The remaining two cycles of year one focussed on different content topics: EoEC and light respectively. Through the 5 cycles teachers reflected on how they interacted with LPK and sought ways to work with this knowledge in a more meaningful way. Cycles 4 and 5 took place in year 2 and were concerned with the same work: EoEC and light. Changes that were effected in the 'plan' meetings included: reviewing and reordering of activities, considering the questions that are asked. Cycles 4 and 5 took place in year 2 and were concerned with the same work: EoEC and light.

Teachers were interviewed using a semi-structured protocol three times during the project: at the start, end of year one and end of year two. Data from the interviews, together with data from classroom observations, reflect and plan meetings was recorded using an audio recorded. All lessons forming part of the research were recorded using a video camera. Data were transcribed and coded using two analytical frameworks: a tool for Analysing Meaning Making Interactions in Science Classrooms (Mortimer & Scott, 2003) and a hybrid of Zeichner and Liston (1987) and (O'Sullivan, 2002) levels of teacher's reflective practice. Through the cycles teachers explored ways to include an interactive dialogic communicative approach into their teaching repertoire, as in Cycle 1 teachers opted to use an interactive authoritative dialogic communicative approach. Teachers reflected on the levels of questions asked, the: 'I', in IRE and IRPRE patterns of interaction. Learners responses ('R') were coded using the 'Coding Scheme for Learner Contributions' developed by Pimentel and Mc Neill (2013). Learners responses were coded as one of the following: no thought, single words, or phrases, complete thoughts and thoughts with reasoning. Teacher moves ('E) were coded (probe, cut off, elaboration, toss back, procedural or evaluative) using the 'teacher move' codes described by :

Chapter 4

How do teachers work with learners' prior knowledge in their baseline practices?

4.1 Introduction

Science classrooms should be exciting places of learning, discovering, and understanding the world that we live in. Having lived in the world for some 13 years and attended school for at least seven years, grade 8 learners enter the science classroom with some ideas about natural phenomena. Education theory which is grounded in constructivism has teacher and learner engagement with this LPK a prerequisite for meaningful learning to take place. The well-known quote by educational psychologist David Ausubel says it best:

> *If I had to reduce all educational psychology to just one principle, I would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly.*
>
> *(Ausubel, 1968, p. iv)*

Vygotsky (1978) stresses for learning to occur, opportunities need to be created where there is a blending of 'spontaneous concepts' with 'science concepts.' Where spontaneous concepts refer to LPK and science concepts refers to new knowledge to be taught. For new knowledge to become meaningful opportunities should be created that allow learners to compare, contrast, interpret and evaluate the new knowledge with their existing knowledge (Mortimer & Scott, 2003). This chapter, chapter four is concerned with exploring how Grade 8 Natural Sciences teachers engage with LPK. I wanted to find out: in their baseline teaching practices, how do teachers interact with LPK? To unpack this research question, I asked three sub-questions: first, when in their lessons do teachers explore LPK? Second, what are the sources of LPK teachers interact with during lessons? Finally, what are the patterns of interaction teachers use when engaging with LPK? I have structured the chapter to first consider the purpose and content of each teacher's lesson. I will continue the chapter by answering each of the three sub-questions and conclude by then answering the main research question this chapter seeks to answer: in their baseline teaching practices how do teachers interact with LPK?

4.2 Baseline Lessons

Having accepted the invitation to participate in the research, I asked teachers to decide on an hour lesson that would be their baseline lesson of the project. Teachers were free to choose the content and I did not prescribe any education theory or teaching approach. However, when inviting the teachers to participate in the research they were made aware that the purpose of the project was to explore ways to engage with LPK. Further, I had interviewed the teachers a week before recording their baseline practices and had interrogated the value they place on interacting with learner prior knowledge and asked about their teaching practice and probed their thoughts on how meaningful learning can be achieved. Being aware of the purpose of the project may have influenced the decisions teachers made when choosing what to include in their baseline lesson. I was also aware that it is likely that both teachers and learners wanted to put their best foot forward as this was the first lesson that was recorded, and the Hawthorne effect was a reality. Whilst teachers tried to keep things ‘normal’, having a second teacher recording and making notes at the back of the class is unusual and difficult to ignore. For instance, Luke made the following comment to his learners when greeting them at the door just before the lessons started:

> *Right, don't forget to comb your hair. It's movie day today.*
>
> *Luke Baseline lesson*

I will briefly discuss the content and purpose of the lessons for each teacher: Adele, Kate, Luke and myself (Jenny). All lessons were an hour long and were recorded in the same week. At the time of the recording teachers were slightly out of sync as far as curriculum coverage and so content varied amongst the teachers. Having observed and recorded teachers teach the lesson of their choice, data were transcribed using ‘turns’ to identify when something happened, for instance a different person started talking, someone walked in the class or that learners in the class laughed. The most common reason for a change in turn was a change in the participant contributing to the discourse.

4.2.1 Adele

Adele’s lesson was an introductory lesson to static electricity. The purpose of her lesson was for learners to understand that static electricity is caused by an imbalance of charge, and this may cause objects to attract or repel each other. Adele started the lesson exploring concepts such as friction, the structure of the atom and everyday examples of where static electricity occurs. Adele continued the lesson by having learners consider an atom with an imbalance of charge and demonstrated this by rubbing a balloon to her hair. Rubbing the balloon caused the balloon to gain electrons, becoming negatively charged. Adele's hair lost electrons becoming positively charged. She then interrogated how objects repel and attract each other, by bringing two charged balloons towards each other and bring the balloon towards her hair. Learners were placed in small groups where using their textbooks they carried out the same experiment Adele had demonstrated. The lesson was concluded with a report back by groups on the results and conclusion of their experiments.

A total of 517 turns occurred in Adele's lesson as she asked learners many questions. Learners in her class were eager to respond.

4.2.2 Kate

Kate's lesson was the last theory lesson to complete the content: density. Kate started her lesson by probing learners on their understanding of mass and volume and how these concepts relate to density. She then moved on to revise the density equation. Kate showed the learners a short video on making a density tower. The following day learners were going to work in groups and make a density tower using liquids and solids of different densities. Learners were asked to move to the group they would work in the following day and decide on the division of labour for the practical. Having prepared for the following day's lesson learners were asked to return to their whole class teaching positions where answers were checked on homework focused on using the density formula. On noticing most learners had not completed the homework activity, Kate gave learners an opportunity to do this.

Whilst learners in Kate's class were co-operative and keen to give answers, when it came to completing homework and having books at school, this was a challenge. Kate interacted with her learners throughout the lesson with a total of 442 turns occurring.

4.2.3 Luke

Luke was explicit that he was starting a new section: Energy and change. He began the lesson by exploring learners' understanding of the term 'energy'. Luke then moved the lesson to consider what is meant by 'static electricity' and briefly explored the structure of an atom, and the consequence of an imbalance of charge. Learners were given an opportunity to rub a plastic pen in their hair and pick-up small pieces of paper. This led to a discussion on the terms 'attract' and 'repel'. In this introductory lesson, Luke then turned the whole class discussion to current electricity. He spent a lot of time explaining various components of simple circuits, (switch, buzzer, light bulb and motor). Having recognized the components, learners were reminded how to draw electrical circuits. Luke ended the lesson by having learners work in small groups and connect a simple circuit that included a lamp.

Whilst most learners were co-operative during the lesson, Luke had one learner, Trevor, who frustrated Luke as he was disruptive by shouting out irrelevant answers many times throughout the lesson. Luke's lesson was predominantly whole class teaching with 547 turns occurring during the hour.

4.2.4 Jenny

I chose to teach a lesson that would conclude the content: particle model of matter. Previously I was concerned that learners were struggling to make sense of what was meant by the term 'particle' and I wanted to explore this further before concluding the section. I started the lesson by having learners identify solid objects in the classroom. I then unpacked what was meant by the term 'particle' with reference to water, oxygen and graphite found in pencils. Learners were required to create a table where various macroscopic and microscopic properties of solids, liquids and gases were discussed. The lesson was concluded with learners completing an activity on the properties of solids, liquids, and gases.

My entire lesson was whole class teaching, with many questions being asked to learners. 514 turns occurred during the lesson. Learners were enthusiastic and readily gave answers to questions that I asked.

Having given the reader a sense of what happened during each of the baseline lessons, I will now unpack how teachers interacted with LPK, during their lesson. I start by discussing when in their lessons LPK was explored? I will then discuss the sources of LPK teachers drew on concluding the chapter with the patterns of interaction teachers used when engaging with LPK.

4.3 When in their lessons do teachers explore LPK?

Before discussing when teachers created opportunities to engage with LPK, I will discuss how I coded instances where teachers interacted with LPK as this allows me to track when interactions with LPK occurred. I will then discuss when in their lessons teachers interacted with LPK.

4.3.1 LPK Episodes

From transcripts of baseline lessons instances were identified where teachers explored LPK linked to a science concept. I refer to these instances as an LPK episode (see Table 1). When the concept the teacher was exploring changed, a new LPK episode was recorded. In Table 9, I have stated the number of LPK episodes per teacher and the concept teachers. chose to explore. I have also given the turn number when the interaction started as this will give the reader a sense of where in the lesson the interaction occurred. The number of turns per LPK episode is given to provide a sense of how much exploring the teacher did with respect to LPK of a concept. The number of LPK episodes per teacher was as follows: Adele 9, Kate 3, Luke 5 and Jenny 6.

Table 9 Teacher Engagement with LPK

Teacher and Total number of Turns in Lesson	LPK Episodes	Starting at turn	Number of exchanges
Adele 517 Turns	1. Static electricity	35	7
	2. Energy	45	6
	3. Structure of an atom.	51	54
	4. Static and current electricity.	127	5
	5. Exploring the word: ‘shock’.	128	9
	6. Experiencing a static at home.	138	31
	7. Practical: Static Electricity and hair.	204	29
	8. Exploring the word ‘charge’.	234	12
	9. Neutral and charged atom.	268	22
	Total Number of Exchanges interacting with LPK:		**175**
Kate 366 Turns	1. Mass/Volume Definitions.	17	54
	2. Cream floating in coffee.	161	15
	3. Metals and Non-metals	335	10
	Total Number of Exchanges interacting with LPK:		**78**
Luke 547 Turns	1. Types of Energy	42	88
	2. Static Electricity	135	7
	3. Parts of an atom	142	31
	4. Components of an electrical circuit	321	139
	5. Drawing simple circuits	448	33
	Total Number of Exchanges interacting with LPK:		**298**
Jenny 514 Turns	1. Solid, liquid and gas	40	20
	2. Elements and compounds	92	16
	3. Drawing: ice, water, steam.	205	7
	4. Shape of solid, liquid and gas.	217	9
	5. Explore the word: ‘volume’	229	9
	6. Volume of a solid	259	7
	Total Number of Exchanges interacting with LPK:		**68**

As the content being taught was different amongst the teachers, the nature of what could be explored varied. Further some concepts allow more in-depth interaction than others. Some LPK episodes were much longer, with much exchange between the teacher and learners, whilst others were shorter. For instance, exploring what learners know about the structure of an atom (see Adele, Table 1), allows for more interaction (54 turns), compared to how learners understand the term ‘shock’ (9 turns).

Short LPK episodes typically started with the teacher asking a question leading to a dialogue between the teacher and a learner. Following the dialogue, teachers sometimes wanted to explore the concept more and would open the discussion to the class. An example of such an LPK episode occurred in Kate’s lesson where she wanted to link the scientific concept of ‘density’ to an everyday example learners may be familiar with (see Table 1, Kate, Episode 2). In the LPK episode, 15 turns occurred. The excerpt from the LPK episode is given below.

Turn 161	Kate	*... Who of you have ever put cream on top of coffee before?*
Turn 162	John	*I do.*
Turn 163	Kate	*Who is? So, what do you do when you pour the cream on? John?*
Turn 164	John	*Ma'am, I put it in a circle, Ma'am.*
Turn 165	Kate	*Why do you do that?*
Turn 166	John	*So that it doesn't fall.*
Turn 167	Kate	*So, that is doesn't go in, yes? Right. So, when we whip our cream, what are we putting into it? When we shake it, what are we putting into it? ... When you whip cream guys. Why do you whip cream? What are you doing to it?*
Turn 168	Busi	*You are making it softer.*
Turn 169	Kate	*You are not making it softer. You...guys you're putting air into it. You're putting air into it to make it lighter. So, tell me when you put, when you put um, cream on top of coffee, and the cream stays on top doesn't it?*
Turn 170	Chorus	*Yes, Ma'am.*
Turn 171	Kate	*Why does the cream stay on top?*
Turn 172	Chorus	*Inaudible*
Turn 173	Kate	*So, is it more dense or less dense than the coffee?*
Turn 174	Chorus	*Less dense.*
Turn 175	Kate	*It's less dense, yes?*

Kate Baseline Lesson

Kate started the LPK episode by asking learners if any of them have put cream on their coffee. Initially there is a dialogue between Kate and a learner, John (turns 161- 167). In turn 167, Kate turns the discourse to include other learners. Busi responds in turn 168. Kate then asks questions that result in many learners responding in a chorus answers (turns 170,172 and 174).

Having unpacked what is meant by an LPK episode, I turn to discuss when in the baseline lesson LPK episodes occurred. I have grouped teachers whose lesson was focused on introducing new content together (Adele and Luke) and those who were concluding a topic together (Kate and I).

4.3.2 Lessons introducing new content: Adele and Luke

Adele and Luke's lessons were both focused on starting the new strand of the NS CAPS curriculum: Energy and Change (Department of Basic Education, 2011). The Natural Sciences curriculum is divided into four strands: Life and Living, Matter and Materials, Energy and Change and Planet Earth and Beyond. Static electricity is the first topic taught in the Energy and Change strand. Adele and Luke both gave learners a short time to complete a practical activity, lasting about 10 minutes, the balance of their lesson was whole class teaching. Both teachers interacted with learners, as is evident from the 517 turns and 547 transcribed for Adele and Luke's lessons, respectively.

All of Adele's interaction with LPK, occurred in the first 20 minutes of the lesson. The last interaction happening on turn 268, 19 minutes into the lesson, lasting for just under 2 minutes. In this LPK episode Adele explored the structure of a neutral lithium atom. The LPK episode with the greatest number of turns (105 turns) was the second one. As in the last LPK episode Adele was exploring the structure of the atom in this one too. This LPK episode occurred 4 minutes into the start of the lesson and lasted for 3 and a half minutes.

Luke interacted with LPK, throughout his lesson (see Table 1). Luke's last LPK episode, lasting 6 minutes, ended 14 minutes before the end of the lesson. Two of Luke's LPK episodes had many turns: exploring types of energy (88 turns) and components of an electrical circuit (139 turns). The LPK episode concerned with types of energy started 5 and a half minutes into the lesson and lasted 6 minutes. The longest LPK episode occurred half-way through the lesson, was focused on components of a circuit, and continued for 14 minutes, with 139 exchanges occurring.

Both Adele and Luke explored LPK in the first half of their baseline lessons. Adele moved her lesson to focus on new content in the second half of the lesson. This contrasted with Luke, who continued to work with LPK well into the second half of his lesson. I will now discuss when teachers (Kate and Jenny) who chose a lesson concluding a topic interacted with LPK during their lesson.

4.3.3 Lessons concluding a topic: Kate and Jenny

Kate interacted less with her class compared to me, where Kate's lesson had 366 turns, compared 514 turns in mine (see Table 1). Kate's first LPK episode occurred 3 minutes into the lesson and lasting for 4 minutes. In this LPK episode Kate explored what is meant by the terms: volume, mass and weight. Kate's second LPK episode occurred 16 minutes into the lesson, where she discussed cream floating on coffee. Her final LPK episode occurred 35 minutes into the lesson and continued for less than a minute. In this LPK episode learners had calculated the density of various elements. Using a periodic table that included the density of the element, learners were asked to determine the element. Whilst working with the periodic table Kate asked learners to use the periodic table to state whether the element was a metal, non-metal or metalloid, something that was taught earlier in the year.

I interacted with LPK 5 minutes into the lesson, where the three states of matter were explored: solids, liquids, and gases. This LPK episode lasted for 2 and a half minutes. The first LPK episode had the greatest number of turns. The final LPK episode in Jenny's lesson took place 29 minutes into the lesson and lasted for less than a minute. In this LPK episode learners were struggling to understand that solids have a volume.

Both Kate and I spent the first part of the lesson exploring LPK, using about the same number of turns 78 turns for Kate and 68 turns for Jenny.

To answer the question, when do teachers interact with LPK, I grouped teachers together based on the purpose of their lesson, as I thought teaching content at the start of topic may result in interacting with LPK in a similar way compared to how teachers interact with LPK in a lesson that is concluding a topic. Whilst Kate and I showed similar trends, in that both interacted with LPK for the first half of their lesson, no trend could be identified with teachers who were starting a new topic.

Luke interacted with LPK from the start of the lesson to almost the end of the lesson. However, like Kate and Jenny, Adele interacted with LPK only in the first half of the lesson. Kate, Adele and Jenny are Life Sciences teachers whilst Luke is the Electrical Technology teacher and considered an expert on the topic ‘electricity’. Perhaps a reason Adele, Kate and I interacted only in the first part of the lesson was because this was not their subject specialty. They may be unaware of possible alternative conceptions learners hold onto as well as the knowledge learners may already have.

4.4 What sources of LPK do Natural Sciences teachers draw on?

Having identified LPK episodes, the source of the LPK was coded. Most LPK episodes were concerned with teachers engaging with LPK that was from the same source, within an LPK episode. For instance, an LPK episode may have been concerned with interacting with LPK originating only from formal instruction. Here the teacher asked questions to explore content that was taught earlier in the year during their own class or possibly learnt in a different subject, for instance the Maths class. Where the LPK being explored in the same LPK episode was from the same source I coded the source of the LPK only once, for example formal instruction. Table 2 below indicates the various sources of LPK teachers interacted with.

Table 10 Sources of LPK teachers interacted with.

	Formal Instruction	**Informal Learning**	**Language**	**Everyday Experiences**
Adele	4	1	2	2
Kate	2			1
Luke	4			1
Jenny	4		1	3

A few instances occurred where a teacher referred to two sources of LPK within the same LPK episode. Where this occurred, I coded each source separately. This is the reason for more ‘sources of LPK’ being coded than what there are LPK episodes (see Table 1 and Table 2). This happened in Adele’s lesson where she was exploring learner understanding with respect to the structure of an atom. Whilst exploring LPK originating from formal instruction, Adele wanted to include a representation of the structure of an atom that she thought might be familiar to learners. Adele asked learners if they watch a television series, ‘The Big Bang Theory’, that has an animation of the structure of an atom in its title sequence. This was the only instance a teacher included interacting with knowledge gained from informal learning in their baseline lesson.

All teachers interacted with LPK that came from formal instruction and everyday experiences (see Table 2). Adele engaged with the most varied sources of LPK, including formal instruction, everyday experiences, informal learning, and language. Kate and Luke only interacted with LPK that came from formal instruction and everyday experiences. Like Kate and Luke, I included both formal instruction and everyday experiences sources of LPK. However, I also included one instance where I explored language as a source of LPK.

I continue my discussion by exploring each source of LPK in more detail, starting with formal instruction as it was the source of LPK most used by all teachers.

4.4.1 Formal Instruction

The most common source of LPK teachers drew on was from learner's formal instruction. Formal instruction could mean, knowledge learners have gained from primary school or knowledge gained from the current year, either in NS classroom or another subject, for instance in the Maths or Technology class. The excerpt below is an example of such an instance, where Luke informs learners that they were previously taught what a light emitting diode is.

Turn 387	Luke	*How many of you can identify that one? You've done that in Technology. It is called light emitting diode. You've actually, as a matter of fact, done that in primary school. I know. I know you've done that in primary school. What is that?*

Luke Baseline Lesson

Having informed learners, that they have been introduced to a light emitting diode in primary school, Luke continues his teaching to consider the next electrical component. Teacher interactions with LPK, will be discussed in more detail in section 4.5. In their first interviews Adele, Kate and Luke mentioned learners gaining knowledge from formal instruction, specifically knowledge gained from primary school. The excerpt below is Luke's response to being asked how he starts a new topic.

> *Yes, you'll give them a little bit of background. 'Guys, have you done this before in Primary School? Most of you should have done it. If you have not done it put your hands up. If you have done it fine.' And then they say: 'Yes, we've done it. No, we haven't.'*

Luke First Interview

Whilst all teachers acknowledge learners bring with them knowledge gained from formal instruction, both Kate and Luke complained that learners struggle to recall concepts that have been previously taught.

> *I think they have all done it previously. Some of them just can't remember doing it.*

Luke First Interview

In the excerpt below Kate is frustrated that whilst many learners are unable to recall content previously taught, those that can do not form part of the class discussion.

> *So, you ask a question, and they start talking about this and the they start talking about that. And, but it doesn't work like that because um, to be deadly honest they don't remember what they have learnt the previous year. Um and if they do, they don't put up their hand and voice it. So, you end up speaking a lot to them and then they just sort of take in the information. Or in some cases don't take in any information.*

Kate First Interview

The preferred source of LPK teachers interacted with was that which comes from formal instruction. Teachers were aware that learners come to the NS class having been taught concepts in previous grades, other subjects and earlier in the year in their own subject. However, they were also aware that many of these concepts learners may not remember. Informal Learning

Adele was the only teacher to refer to knowledge learners may have gained from informal sources. Whilst discussing the structure of an atom, Adele refers to an animation of the structure of an atom that occurs in the title sequence of the television series 'The Big Bang theory', (see excerpt below).

Turn 101	Adele	*Do you watch the Big Bang Theory?*
Turn 102	Amanda	*Yes.*
Turn 103	Adele	*Ok, do you watch the Big Bang Theory? Do you know like in the introduction of that song, they have a, they have a...*
Turn 104	Amanda	*Yes*
Turn 105	Adele	*Yes. Yes, and one of those scenes is the nucleus, with, with the electrons going around it. Do you remember that?*
Turn 106	Amanda	*Yes*
Turn 107	Adele	*Have you seen that, right? So, I hope that movie is playing in your heads now isn't it?*

Adele Baseline Lesson

In this instance Adele only interacts with Amanda, when asking if she is familiar with the series and the animation of the structure of the atom. No other instances of engaging with concepts learners may have gained from informal learning occurred in any of the other teachers baseline lessons.

4.4.2 Language

Adele and Jenny were the only teachers that explored instances where language could be a source of LPK. Both seemed to be incidental, in that both occurred when a learner answered a question. In the excerpt below Adele asks Tshidi, what she understands by the term charge'? Tshidi response is linked to charges being laid against a person (Turn 239). Adele allows a second learner Basi to respond, who now speaks of charging a cell phone (Turn 241). Adele then adds to the various ways the word 'charge' is used by stating 'How's about when they charge you at the shop?' (Turn 242). Adele allowed quite a lot of back-and-forth discussion, exploring the various ways the word 'charge' is used.

Turn 238	Adele	*Charges. What are charges, Tshidi?*
Turn 239	Tshidi	*This is when police charges with you.*
Turn 240	Adele	*What do you mean charges you? Are you talking about legal charges? Aren't you? Like when you get charged for murder or something.*
Turn 241	Basi	*And when you charge your phone.*
Turn 242	Adele	*And when you charge your phone? That's an interesting one. How's about when they charge you at the shop?*
Turn 243	Basi	*Laughing*
Turn 244	Adele	*But we're talking about electricity, and we're talking about atoms and we're talking about positives and negatives and protons and neutrons. So, what charges do you think we are talking about?*

This contrasted to the how I explored LPK whose source was language. About 17 minutes into my lesson, I asked Keenan, what he understands by the term 'volume' as I was focused on comparing the volumes of a solid, liquid and gas vary?

Turn 229	Jenny	*Think about the ice, did it have a set volume? What do we mean by volume anyway? Keenan?*
Turn 230	Keenan	*Ma'am?*
Turn 231	Jenny	*What's volume?*
Turn 232	Keenan	*Sound.*
Turn 233	Jenny	*Sound? …Oh, like sound. Ok, let's move away from the Indian cars. From their loud volume that they share with us on Friday afternoons. Ok, what, what's another kind of volume we can talk about?*
Turn 234	David	*Ma'am, like space and stuff.*
Turn 235	Jenny	*The space?*
Turn 236	David	*Yes, like...*
Turn 237	Jenny	*Ok, explain what you mean David.*
Turn 238	David	*Ma'am I think it's like a glass of water. The space in that glass.*

Jenny Baseline Lesson

Keenan replies is ‘Sound’ (Turn 232). This unexpected answer took me by surprise as it seemed liked a nonsense answer. I repeated Keenan’s reply ‘sound’ as a question. I then recognized that Keenan was referring to volume as in the level of noise. I did not prompt Keenan any further on his answer and moved the whole class discussion to explore volume, as planned where I ask: ‘What’s another kind of volume we can talk about?’ (Turn 233)

4.4.3 Everyday Experiences

All teachers interacted with everyday experiences as a source of LPK (see Table 2) during their lesson. I have chosen an excerpt from Luke’s lesson as an example of an instance where everyday experience was used as a source of LPK. Halfway through his lesson, Luke projected images of various electrical components onto his screen. As the electrical component was projected Luke asked learners questions regarding the component. In the excerpt below Luke projected an image of two switches and explored various electrical devices that would use a push button switch.

Turn 363	Luke	*Ok, what is that thing?*
Turn 364	Chorus	*A light bulb. A buzzer.*
Turn 365	John	*A switch*
Turn 366	Luke	*Those are both the same. That is a push button switch. Have look at it. Can you see that?*
Turn 367	Carl	*Oooh. Yes Sir. No.*
Turn 368	Luke	*Can you see the little red thing there? Ok, you press the button. Where would you find something like that?*
Turn 369	Phindi	*At a theme show.*
Turn 370	Philip	*Remote.*
Turn 371	Trevor	*In a factory.*
Turn 372	Luke	*No, you can't just say factory. I find um machines in a factory.*
Turn 373	Trevor	*In the remote.*
Turn 374	Brian	*In the*
Turn 375	Luke	*Where you have to press the button for it? What about a doorbell?*
Turn 376	Brenda	*Yes*
Turn 377	Luke	*They come to your house and the press the button. It makes contact and the bell goes. Now this is another type of switch. What type of switch is that? Common old household switch, hey?*

Luke Baseline Lesson

Adele explored various ways learners have experienced a static electricity, whether it be by hair standing on end or an electric shock. The only everyday source of knowledge Kate investigated was the floating of cream on coffee. In my lesson, there were 3 instances where I referred to the everyday experiences of learners as a source of knowledge. In the first instance I asked learners to place their fingers on a solid object around them. About 20 minutes into the lesson learners were asked to compare water in its three states. Later in the lesson learners were struggling to understand the volume of a solid. In this instance I use the volume of ice cream as it would be in a container to try and link a volume the learner may be familiar to the abstract quantity of volume.

Having discussed the various sources of LPK, I continue by unpacking how teachers interacted with LPK, by interrogating the patterns of interaction teachers used when engaging with LPK.

4.5 Patterns of interaction teachers use when engaging with LPK?

To unpack the patterns of interaction teachers used when engaging with LPK, I have coded the following regarding the interactions that occurred when teachers' explored LPK : first the type pattern of the interaction (IRE vs IRPRE) (See Chapter 3.10.1), second learner contributions, the 'R' (See Chapter 3.10.1.2) finally I considered the teacher moves the 'E' and 'P' (see Chapter 3.10.1.2). Before discussing the patterns of interaction, learner contributions and teacher moves for each teacher I will consider the combined results for all teachers for each of the three aspects mentioned.

4.5.1 Patterns of Interaction

Where teachers initiated a discussion with learners whilst exploring LPK, the pattern of interaction was coded as either IRE or IRPRE. Table 3 is a summary of the total number of IRE or IRPRE patterns of interaction that occurred.

Table 11 Patterns of Interaction: Baseline Lessons

	IRE	**IRPRE**	**Total**
Adele	25	15	40
Kate	12	9	21
Luke	44	28	72
Jenny	11	8	19
Total	**92**	**60**	**152**

Luke had the greatest number of interactions with learners (72), being almost double coded for the teacher with the next highest number of interactions: Adele, (40). Kate and I had about the same number of interactions with learners (20). For all teachers, the preferred pattern of interaction was IRE (see Table 11), being almost 60% of the patterns of interaction (see Figure 6). Essentially the four teachers worked in remarkably similar ways when interacting with learners, preferring to ask a question, have learners respond and then evaluate that response.

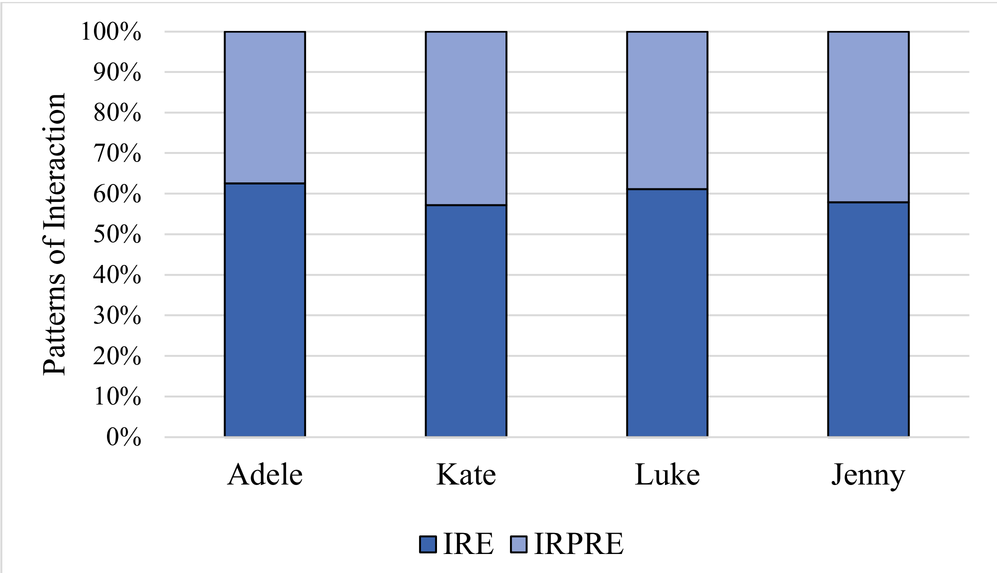

Figure 6 Patterns of Interaction: %IRE and % IRPRE

The excerpt taken from Kate's lesson, illustrates an IRE pattern of interaction. Here, Kate asks the class to define the term 'mass'. John replies with a single word: 'weight'. Kate's response is to evaluate John's incorrect response by stating that '*mass is not the same as weight.'*

Turn 29	Kate	*... Ok, so who can tell me what mass is?*	I
Turn 30	John	*Weight*	R
Turn 31	Kate	*Mass is not the same as weight.*	E

Kate Baseline Lesson

Where IRE patterns of interaction, are dominant, the communicative approach teachers are using is interactive authoritative (Mortimer & Scott, 2003).

Instances occurred during interactions where teachers explored LPK more deeply, by either asking a learner to explain their meaning using probing questions or have different learner explain their meaning to the same question. When the latter occurred, I coded this as a 'toss back' vs a 'probe', teacher move. The excerpt below, from my baseline lesson is an example of where a toss back occurred. I coded this pattern of interaction as an IRPRE interaction. In this excerpt I ask the learners how they would represent the gaseous state of water.

Turn 207	Jenny	*Like water in a glass. And what does gas water look like?*	*I*
Turn 208	Mohamed	*Steam.*	*R*
Turn 209	Jenny	*Steam, so how are we going to show that?*	*P Toss back*
Turn 210	Diane	*Kettle.*	*R*
Turn 211	Jenny	*Ah, a kettle, how are we going to draw a kettle?*	*P Toss back*
Turn 212	David	*Ma'am you can just, put, draw the steam coming out, ssshhhh.*	*R*

Jenny Baseline Lesson

In turn 208 Mohammed suggests that water in the gaseous state looks like steam. I explore a little further and ask Diane to suggest a way to represent steam. Her reply is a single word 'kettle' (turn 210). I then ask someone else to suggest how to draw a kettle to represent steam. David answers in turn 212, that 'you can just, put, draw the steam coming out.'. And makes a sound to demonstrate what he means. Interactions that include more than one learner explaining their meaning, result in many ideas being exchanged and as such many voices are heard and this communicative approach would be considered interactive dialogic.

IRE was the preferred pattern of interaction by all teachers in their baseline practices. I will now consider the 'R', learner contributions in more detail.

4.5.1.1 Learner Contributions: the 'R' in IRE and IRPRE

Learner utterances during the lesson were coded using the coding scheme described by Pimentel and Mc Neill (2013) with the intention of identifying the completeness of learner responses. Learner responses that included reasons for their replies were coded '3', those that were complete thoughts were coded '2'. Responses that were single words or phrases were coded '1' and those where no thought was evident were coded '0'. (See Chapter 3.10.1.2). A few responses could not be coded as they were inaudible. The number of chorus responses was recorded. All chorus responses were coded 1. Note: the chorus responses are also included in the tally of level '1' responses.

Table 12 Coding of Learner Contributions: Baseline Lessons

	0	**1**	**2**	**3**	**Chorus**
Adele	4	53	13	6	21
Kate	1	22	9	4	6
Luke	17	67	34	8	10
Jenny	2	26	5	1	9
TOTAL	**24**	**168**	**61**	**19**	**46**

All teachers asked questions to the whole class throughout their lessons. Lessons structured in this way are more interactive compared to a non-interactive authoritative, lecture style lessons, where learners are passive participants. Most learner responses were single words or phrases (see Table 4, level '1'), with many being chorus answers. This was because teachers tended to ask questions that were of a low order. In some instances, teachers phrased the question in such a way, learners were able to guess the answer. An example of such an instance is taken from Adele's lesson on static electricity. Here Adele asks learners to predict what would happen if a charged balloon was brought close to her hair, as she had just demonstrated what happened when the balloon was brought close to her waist coat.

Turn 232 Adele *Hmmm. So... if my balloon is repelling my waist coat what would it do with my hair?*

Turn 233 Chorus: *Attract*

Adele Baseline Lesson

Since learners had just observed the balloon repelling the waist coat, when asked what would happen when the balloon was brought close to her hair, they called out 'attract' (Turn 233), assuming it would cause an opposite effect.

Few (22%) learner responses were coded as being a 'complete thought' and even fewer (6%) were coded '3' being a 'thought with reasoning'. Learners were seldom asked to explain their meaning (see Table 4). I now consider the move teachers made following a learner utterance.

4.5.1.2 Teacher Moves: the "E" in IRE and IRPRE

Having initiated an interaction, by asking a question, teachers then had to decide what move to make having heard the learner response: they could evaluate, support or discourage exploring the learner's meaning. As described in Chapter 3 teacher moves were coded using the categories defined by Pimentel and Mc Neill (2013):: cut off, probe, toss back and elaboration, (see Chapter 3.10.1.1, page 85) as well as the two additional categories: 'evaluation', and 'ignore'.

Table 13 Teacher moves: Baseline Lessons.

	Ignore	**Cut Off**	**Toss Back**	**Probe**	**Elaborate**	**Evaluate**
Adele	0	1	18	11	6	20
Kate	0	0	13	4	3	12
Luke	2	10	21	5	14	30
Jenny	0	0	8	4	8	18
TOTAL	**2**	**11**	**60**	**24**	**31**	**80**

The most common teacher move from all teachers was ‘evaluate’, followed by ‘toss back’. In many instances, where a learner responded with the answer the teacher was hoping for, the teacher would acknowledge the correct answer and move the lesson forward. The excerpt below, taken from my baseline lesson is an example of one such instance.

Turn 263	Jenny	*... Does the liquid have a definite volume?*
Turn 264	Chorus	*Yes.*
Turn 265	Jenny	*Yes, it does. You could've measured off exactly the volume in the liquid. It doesn't have a definite shape, because it takes on the shape of the container. But the volume stays the same.*

Jenny Baseline Lesson

I start the interaction by asking a yes/no question: ‘Does the liquid have a definite volume?’ Learners (in chorus) reply with the correct answer: ‘Yes’. I evaluate the correct chorus response by reiterating what was replied and move the discussion onto considering whether liquids have a definite shape. The opportunity to explore what ‘the volume of a liquid’ means was not used.

Where a learner gave an incorrect response, teachers would sometimes toss back the question to other learners. The excerpt taken from Kate’s lesson is an example of where this happened.

Turn 49	Kate	*Ok, and what is mass?*	Initiate
Turn 50	Andrew	*Mass is the amount of a certain object that weighs.*	
Turn 51	Kate	*Ok, John. Are you going to say something different?*	Toss back
Turn 52	John	*Yes Ma'am.*	
Turn 53	Kate	*What were you going to say?*	Probe
Turn 54	John	*Mass is the amount of space like, that a object has.*	
Turn 55	Kate	*No, no, not the amount of space. Ok, remember, mass is the amount of matter, that something is made up of. Yes? Ok. So, all of you guys are made up of atoms, yes?*	Evaluate

Kate Baseline Lesson

Kate is wanting to explore learner understanding on the concept ‘mass’, and asks the question ‘What is mass?’ (Turn 40) Andrew replies with an alternative conception. Kate responds by allowing John to explain his understanding of the concept. However, when both learners don’t give Kate what she is looking for, she evaluates John’s response with a ‘no’ and then provides her own definition (turn 55).

Luke was frustrated by a few disruptive learners in his class. He was familiar with their behaviour and did not want to encourage poor behaviour, as a result he cut off learner responses and was the only teacher to ignore a learner response (see Table 5).

Having given the combined results for all teachers, I will now unpack how each teacher explored the knowledge learners bring with them to class.

4.5.2 Adele

In her interview at the start of the project Adele explained that she spends time engaging with learners exploring their understanding of concepts taught in primary school. In the excerpt taken from the interview Adele describes how she probes learners to explore their LPK.

> *Like for instance when we started Matter and Materials, um, I needed to know... what they had learnt before. I needed to know what their primary school teachers had covered. Um, and so I started asking them have you guys ever seen that thing before.... periodic table? ... And depending on their answers, depending on what kind of question I ask them after that. Um, but I do generally ask them questions like 'What do you think of this? And how does this happen? And all the rest of it?'*
>
> *Adele First Interview*

Adele's approach to her lesson was to use whole class discussions, asking learners questions throughout the lesson. She positioned herself as the authority in the class, discussions moved as she directed it. This is evident from the predominance of IRE pattern of interaction (63%) compared to IRPRE (37%) patterns of interaction coded when she worked with LPK (see Figure 6).

Many of the questions Adele asked were of low order, resulting in 28% of the answers being chorus answers (code 1). Four learner responses (5%) were coded '0' in that learner replies were not meaningful. Most, 70% of learner responses were merely words or phrases (code 1). Six instances occurred where learners answered with a complete thought that included reasoning and 13 learner responses were complete thoughts where justification was given (see Table 4).

The most common 'teacher move' Adele used was evaluation (35%). Such teacher moves frame lessons as being authoritative, as learner responses are evaluated by the teacher, with a correct science concept being sought. Where learners gave answers which were correct but lacking information Adele used this opportunity to either probe the learner for more detail, toss back the response to another learner or she elaborated on the response (see Table 5).

In the excerpt below, taken at the start of the lesson, Adele explores LPK, using both 'toss backs' and 'elaborate' to unpack a possible cause of static electricity.

Turn 35	Adele	*So now grade 8s, I want to know, you've all learnt about static electricity before, haven't you? Gr 6 hey? You guys did this?*	I
Turn 36	Chorus:	*Yes.*	R Chorus
Turn 37	Adele	*So, what do you remember about it? Yes Naledi?*	Toss back
Turn 38	Naledi	*Static electricity is the electricity, is like when you rubbed two things like to create a electricity.*	R
Turn 39	Adele	*And what is the rubbing called? Yes Queen?*	Toss back
Turn 40	Queen:	*Friction.*	R
Turn 41	Adele	*Friction. Ok. So, anybody's hands cold? My hands are cold right? So, what you're going to do for me. Take your hands and you're gonna to rub them together. What's happening?*	Elaborate

Adele Baseline Lesson

In this excerpt Adele first asks a low order, yes/no question in turn 35: 'You've all learnt about static electricity before, haven't you?' The class responds as a chorus in turn 36: 'yes'. This is their only option, unless they say 'no' and are wanting to be singled out. Adele then uses two 'toss back' moves to get to the answer she was seeking: friction. Once Queen replies 'friction', (turn 40), Adele, then demonstrates friction, by rubbing her hands together and gets the learners to do the same. In this turn (turn 41) Adele is demonstrating what is meant by friction and was coded as an 'elaborate' teacher move.

Adele preferred to explore LPK using the IRE pattern of interaction. As most of the questions she asked were of a low order, learner responses were mostly few words or phrases. Few instances occurred where a learner responded to a question with a complete thought that justified the thought. Few instances occurred where Adele explored learner understanding using probes and toss backs. Adele moved her lesson on its pre-determined path opting to by evaluate learner responses either being correct or incorrect, without exploring what learners know further.

4.5.3 Kate

When Kate interacted with LPK, this was using both the triadic IRE and IRPRE patterns of interaction (see Figure 6). Kate was the authority in her class, asking many questions, seeking learner responses that agreed with accepted science knowledge. Many of Kate's questions were of a low order, not requiring much thought on the part of the learners, as such 17% responses were chorus and just less than two thirds of the learner responses were categorized as code 1 (see Table 4), i.e., one word or a phrase. Only four student contributions were coded as being a complete thought with an explanation (see Table 4).

Kate tended to phrase her questions in a way that learners knew they needed to agree with her. The excerpt below is taken from the start of the lesson. In both the instances when Kate spoke (Turn 61 and Turn 63) she phrased her question as a yes/no question, with learners being aware of the answer Kate was seeking.

Turn 61	Kate	*Volume, ok. You guys have all learnt about area?*
Turn 62	Chorus	*Yes, Ma'am.*
Turn 63	Kate	*Yes, in Maths. You've all learnt about area. I know Miss Harris has taught it to you Gr 8s. So, you guys all learnt about area. In this classroom, do you agree that the volume of this classroom would be greater than that of the storeroom?*
64	Chorus	*Yes, Ma'am.*

Kate Baseline Lesson

There was an implicit understanding if a learner disagreed with Kate, it was likely that they would be asked to explain their answer, something they wanted to avoid.

Kate's preferred teacher moves were 'toss backs' and 'evaluate, counting for 80% of Kate's responses (see Table 5). The excerpt below is an example of how Kate used probes and toss backs to guide learners into providing responses she was looking for. In this interaction Kate was exploring what is meant by the term 'mass?'

Turn 23	Kate	*Yes, ok. So, who can remember what mass is?*	Initiate
Turn 24	Andrew	*How heavy or light something is.*	
Turn 25	Kate	*Sorry?*	Probe
Turn 26	Andrew	*How heavy or light something is.*	
Turn 27	Kate	*You say " How heavy or light something is." in relation to what?*	Toss Back
Turn 28	Lindo	*Material, like Ma'am, like, matter is like ma'am, plastic ma'am, you put it in the water and it in water and it is going to float.*	
Turn 29	Kate	*Ok, what you are referring to is density. Ok, so who can tell me what mass is?*	Evaluate

Kate Baseline Lesson

Kate starts the discourse by asking the learners: 'who can remember what mass is?' Either she does not hear Andrew's response, or she probes Andrew, by saying 'sorry'. Andrew replies in turn 24, with the exact same answer. Dissatisfied with the answer Kate then use a ‘toss back’ allowing Lindo to express his understanding. However, Lindo, defines mass in terms of an objecting floating. Kate evaluates Lindo’s answer in turn 29, stating that he is referring to density and not mass. Kate then asks the question again, in turn 29 ‘who can tell me what mass is?’

When asked in her first interview how she works with LPK, Kate replied

> *And they want you to be able to draw on the kid’s prior knowledge and um and be able to talk openly about it. So, you ask a question and they start talking about this and the they start talking about that. And but it doesn't work like that because um, to be deadly honest they don't remember what they have learnt the previous year. Um and if they do, they don't put up their hand and voice it. So, you end up speaking a lot to them and then they just sort of take in the information. Or in some cases don't take in any information.*
>
> *Kate First Interview*

Kate’s perception of how she explores LPK, through asking questions and what was observed in the class matched. Kate did not plan activities to challenge alternative conceptions learners may have. Having asked learners to explain their understanding of concepts previously taught, Kate would use these opportunities to either evaluate or elaborate on learner responses. No instances occurred where Kate ignored or cut off learners (see Table 5). Kate elaborated on learner responses three times when working with LPK and probed a learner’s understanding four times. Either way Kate’s voice would be the one heard, explaining and linking previous knowledge with new concepts being taught.

To summarize, Kate used whole class discussions to interact with her learners predominately using the triadic IRE pattern of interaction. Kate tended to ask questions that were of a low order, resulting in many chorus answers. Where individual learners responded to questions the answers were often in single words or phrases that Kate would either evaluate or explore a bit seeking the answer she had planned for.

4.5.4 Luke

Of the four teachers, Luke initiated the greatest number of interactions, 72 (see Table 3), providing many opportunities for learners to make their LPK explicit. 44 of Luke’s interactions were coded IRE compared to 28, IRPRE patterns of interaction (see Figure 6). The communicative approach Luke's used was predominantly interactive authoritative as 61% of his patterns of interaction were coded IRE. Only a third of Luke's teacher moves were to explore learner understanding using either probes or toss backs (see Table 5). Some instances occurred where Luke allowed many learners to contribute to a discussion before evaluating or elaborating on responses. However, some learners were over enthusiastic and spoke out of turn. Consequently, Luke did not hear all responses and some learner contributions were ignored (see Table 5). Present in Luke's class was a disruptive learner, Trevor, who sought attention during the lesson. Luke would either ignore or cut off Trevor's response when Luke considered it irrelevant to what was being discussed.

Whilst Luke encouraged learners to be active throughout the lesson, he had a pre-determined path he wanted the lesson to follow. Where learners responded with a concept he had planned for, Luke tended to interrupt the learner as they were responding and elaborated on what the learner had started. Such teacher moves were coded: 'cut off'. The excerpt below is of one such instance. Here Luke is exploring the structure of an atom and asks the learners in Turn 143 to name the parts of the atom.

Turn 143	Luke	*Remember when, let's talk about the atom for, for a little bit. What does the atom consist of?*	I
Turn 144	John	*Isn't it the positive and negative?*	R
Turn 145	Luke	*Right, it consists of positive and negative charges. What are those positive and negative charges?*	Cut off
Turn 146	Chorus	*Electrons*	R Chorus
Turn 147	Luke	*So, are electrons, negative or positive?*	I
Turn 148	Chorus	*Positive, negative*	R Chorus
Turn 149	Luke	*Electrons are?*	Toss Back
Turn 150	Kinesh	*Electrons are er... negative particles and protons is a positive and a negative.*	R
Turn 151	Luke	*Brill, protons cannot be positive and negative, hey? Right, do a simple little, revision exercise. A simple little revision exercise.*	Evaluate

Luke Baseline Lesson

John replies with a question: 'Isn't it the positive and negative?' (Turn 144). Having heard a concept, he could work with; Luke's next move is a cut off (Turn 145). John is not afforded the opportunity to elaborate on his meaning. Instead Luke initiates a second interaction by unpacking what the positive and negative charges John referred to are: ‘What are those positive and negative charges?’ (Turn 145). Luke explores the charge of protons and electrons in the next few turns, using a toss back move allowing a different learner, Kinesh to respond (Turn 150). Luke reacts to Kinesh’s contribution by starting to praise his response, but soon realizes the second part of Kinesh’s response is not what he was looking for. Luke then evaluates Kinesh’s response stating that: Protons cannot be positive and negative. This type of interaction with learners was common throughout Luke’s lesson. Where a response was correct, the lesson moved forward easily. However, where a learner response was incorrect, Luke would either evaluate it as being incorrect immediately (IRE) or use few probes or toss backs until he got the answer he was seeking.

Many learner contributions in Luke’s lesson were coded as level 1 (53%, see Table 4). In the excerpt given above, all learner responses but one was coded level 1, as they were words or phrases. Kinesh’s response was coded level 2 as this was a complete thought. Luke tended to ask low order question throughout his lesson. Examples of such low order questions occurred in Turns 143, 145 and 147: ‘What does an atom consist of?’. ‘What are those positive and negative charges? ‘So, are electrons positive or negative?’ The questions asked in Turns 145 and 147, are of such a low order, learners responded in a chorus.

Sometimes the questions Luke asked were structured such that learners completed Luke’s sentence. An example of this occurred in Turn 149 where Luke asks ‘Electrons are? In Turn 150 Kinesh’s reply begins by repeating Luke’s question: ‘Electrons are negative’ (Turn 150).

Throughout Luke’s lesson, learners were active participants, as he asked many questions. The triadic IRE was the preferred pattern of interaction. Questions tended to be of a low order resulting in learner contributions being single words or phrases. Many questions were whole class chorus answers. Luke was well prepared for his lesson and was determined to keep it on its path, avoiding any deviations caused by learners responding with alternative conceptions or disruptive learners.

When asked about how he works with LPK in his first interview. Luke explained when teaching a concept that was part of the curriculum of previous grades, he would find out by show of hands which of the learners had been taught the concept. If he discovered learners had not been taught the concept, he would reteach it. The excerpt below comes from Luke’s first interview, when asked how he works with LPK?

'Whose done it before?' They'll put their hands up. 'Who hasn't done it before?' Then we say right 'You need to pay special attention. Here's some information.' I will do an example on the board for them, for the whole class, obviously.

Luke First Interview

Luke also spoke of his frustration about learners not remembering concepts previously taught. He said the following:

But they need to pay special attention. I think they have all done it previously. Some of them just can't remember doing it.

Luke First Interview

Luke acknowledged he did not explore LPK in depth, as if no hands went up, he would move the lesson along its intended path.

Luke	*'Who hasn't done it?' They will put up their hand. 'And who has?' They'll put up their hand. And I'll say: 'Right, now we are going to carry one from this point.'*
Jenny	*Ok. You don't explore it further.*
Luke	*I don't explore it further.*

Luke First Interview

In his baseline lesson, Luke did ask learners about concepts previously taught. If after several questions he found learners understanding was lacking he would re-explain the concept. The excerpt taken from his baseline lesson above (Turns 143- Turn 151) is an example of one such instance. Luke claimed that a problem when working with LPK was, that learners could not remember what they had been taught.

Luke also explained that what might happen is that concepts have not been taught, that should have. This could be because the learners have come from different primary schools and one primary school ignored teaching the concept. Or it could be that within the same primary school not all teachers taught all concepts. As a result, learners taught by different teachers may not have been taught the same concepts. The following excerpt was taken from Luke's interview at the end of the first year.

This is what I am saying. Some schools, they've done it (LPK) *very well. You can see that. Other schools, the kids look at you with a blank expression. They haven't seen this. They haven't done that. Or they've been in a different class in the same school.*

Luke End of Year 1 Interview

How Luke said he interacted with LPK in his interviews and was what was observed in the classroom. Not only was Luke aware of concepts taught in NS classes in previous grades, but also what was taught in other subjects, for instance Technology and Maths. When introducing a concept Luke would ask low order questions to the whole class. On discovering that learners were unfamiliar or had 'forgotten' what previously taught Luke was would use chalk and talk explanations to recap on the 'missing knowledge'. Luke's preferred pattern of interaction was IRE.

4.5.5 Jenny

Before discussing my baseline practices, I would like to be upfront that at the time the lesson was recorded I was aware of the patterns of interaction IRE and IRPRE. However, I was unaware of how the data would be analysed as I had not yet decided on coding. Of the four teachers, I had the least number of instances where I interacted with LPK, 19. Of these 11 were IRE and the remaining 8 IRPRE (seeTable 3). Most learner contributions were coded at the low level 1, with only a single level 3 learner response. This occurred in Turn 238 when David explains his understanding of 'volume':

Ma'am I think it's like a glass of water. The space in that glass.

In his explanation David supported his idea that water in a glass has volume, by referring to the space in the glass. This was a complete thought, with a reason.

In the excerpt below I try and explore volume of a solid, by using an everyday example learners are familiar with, ice cream in a container.

Turn 259	Jenny	*But we're not talking about heating it up to get it to water. We're talking about it being ice. So, if you go, can I go to the shops and buy a set volume of ice cream?*	I
Turn 260	Chorus	*Yes, Ma'am.*	R Chorus
Turn 261	Jenny	*Because that's ice. It's ice cream, it's just frozen milk really? So, can I get a definite volume? Yes. You can measure volume. Can you measure your volume? Can we measure the volume of this table?*	Elaborate I
Turn 262	Chorus	*Yes.*	R Chorus
Turn 263	Jenny	*Length times breadth times height. So, there is a definite volume. Does the liquid have a definite volume?*	Elaborate
Turn 264	Chorus	*Yes.*	R Chorus

Turn 265	Jenny	*Yes, it does. You could've measured off exactly the volume in the liquid. ...*	Evaluate

Jenny Baseline Lesson

All learner responses in the excerpt were yes, no answers: Can I go to the shops and buy a set volume of ice cream? (Turn 259). Can we measure the volume of this table? (Turn 261) Does the liquid have a definite volume? (Turn 263). The questions were of such a low order that learners replied in chorus.

Of the various teachers moves I used to respond to learner contributions, evaluate was the most common (see Table 5). In the excerpt above I end the interaction by confirming the choral answer 'yes' to the low order question I asked in Turn 263, does liquid have a definite volume? Of the 19 interactions that occurred, 18 ended with an 'evaluate' move.

Eight instances occurred where I used the teacher move 'elaborate', two of these occurred in the interaction in the above excerpt. In turn 259, I ask learners if you can buy a volume of ice-cream? The learners respond as a chorus 'yes'. Thinking that learners understand volume better if the material is in a solid form, I elaborate by stating that ice-cream is frozen, implying that it is solid: Because that's ice. It's ice cream, it's just frozen milk really? In the same turn, I answer my own question: can I get a definite volume? Yes. You can measure volume. I did not use this opportunity to explore everyday knowledge learners may have. For instance, I could have asked learners what are the various volumes of ice cream they buy? This may have allowed learners to get a better sense of what is meant by the term 'volume'.

The second time I elaborate in the interaction occurred in Turn 263. I ask learners 'Can we measure the volume of this table?' (Turn 261). The learners respond as a chorus 'Yes' (Turn 262). I then go on to give the learners the formula for calculating the volume of the table: 'Length times breadth times height.' (Turn 263). This type of interaction is authoritative as only one voice is heard, that of school science. Learners were not afforded the opportunity to explain their meaning.

Having written the proposal for my study, I was aware of the various communicative approaches described by Mortimer and Scott (2003) when teaching my baseline lesson, at the same time I wanted my baseline line lesson to be a 'normal' lesson. This may be the reason the down played IRPRE interactions as having learners explain their meaning further is not something I always did. Further, I felt if I focused for too long on one having a learner explain their meaning, their classmates would become disengaged with the lesson.

4.6 Discussion

Whilst the purpose of the four baseline lessons, may be categorized as either introducing a topic, or concluding a topic, it would be hoped that meaningful learning occurred in each classroom. Meaningful learning occurs when opportunities are created allowing learners to link what they know and believe to be true, to new concepts being taught (Scott et al., 2011). All teachers in my study, created opportunities to explore LPK during their lessons.

Meyer (2004) and Mortimer and Scott (2003) reported that expert teachers worked more effectively with LPK, than novice teachers. In my study the expert electrical teacher, Luke worked with LPK, throughout his lesson. The remaining three teachers were Life Sciences teachers teaching Physics components, of the NS curriculum, and only interacted with LPK in the first half of their lessons. At the time of collecting data Adele and Kate had less than 5 years teaching experience and would be considered novices at teaching. However, I had over 20 years of teaching experience, albeit that most years were spent teaching Life Sciences and not NS yet I showed a similar pattern of when I interacted with LPK. All teachers presented their well-planned lessons as a canon of scientific knowledge which needed to be taught. Whilst these lessons were interactive, teaching patterns tended to be authoritative, with teachers asking questions and looking for specific answers.

In answering the first sub question: when in their lessons do teachers explore LPK? The expert, experienced teacher worked with LPK throughout his lesson. Whilst teachers whose expertise lay in the Life Sciences and not the Physical Sciences, explored LPK at the start of their lesson. The second research sub-questions asked: what are the sources of LPK, teachers draw on during their lessons?

In their interview’s teachers acknowledged that learners come to class having learnt something from previous grades and subjects. Like teachers in Lin’s (2015) study, all teachers in my study preferred to interact with LPK acquired from formal instruction. However, teachers expressed frustration trying to explore knowledge gained from previous lessons, as learners were unable to recall what they had been taught and sometimes concepts that should have been taught weren’t. No teacher planned an activity that challenged alternative conceptions learners may have. It is unlikely that all learners have assimilated all topics from previous experiences in a way that agrees with accepted science concepts. Where alternative conceptions became evident during a lesson, interactions with this LPK, was incidental and not planned. If alternative conceptions are not addressed, it is unlikely the learner will make deep meaning of the new concept (Posner et al., 1982).

All teachers referred to everyday experiences as a source of LPK. In most instances the purpose was to relate what learners are familiar with to a concept being taught (Stears, Malcolm, & Kowlas, 2003). Adele and I included working with LPK which comes from language. Adele compared how words, 'cell' and 'shock' used in everyday English, differs with their meaning in science. An instance occurred in my class where the word, 'volume' was explored considering the two ways it is used in science, namely as a measure of the loudness of sound and capacity. Adele was the only teacher to refer to knowledge learners may have gained through informal learning, when she referred to an animation that occurs in the title sequence of a television series.

No instances of interactions with LPK coming from cultural or religious beliefs occurred. For teachers to plan and interact with LPK, they need to be aware of the diverse LPK that might surface once the can of worms is opened. Much of this knowledge may be gained from training, by experience, or the teacher coming from the same cultural or religious background as learners. Some may be unknown to teachers (Ball & Bass, 2000). Where the cultural background of the teacher differs from the learners, it is likely that some of the LPK that comes from the learners' cultural background may be overlooked by the teacher. Perhaps this is the reason Adele did not explore lightening in her lesson on static electricity. Adele is a devout Indian Christian, compared to the many learners she taught who come from an indigenous African cultural background. Indigenous African cultures have many varied ways of explaining lightening. Adele did not use this opportunity to explore these.

In answering the third sub question: What are the patterns of interaction teachers use when engaging with LPK, the pattern of interaction teachers used to explore LPK was analysed: IRE vs IRPRE. In all classes the preferred pattern of interaction was the triadic IRE. This interaction counted for two thirds of the interactions. Teachers were aware learners brought with them some science knowledge and used questions to remind learners what they had previously been taught. Few interactions were coded where teachers explored LPK in depth.

The type of questions teachers ask influence how learners respond. Low order questions result in answers that are single words or phrases, compared to higher order questions where the reply is given as an explanation or prediction (Chin, 2007). In all four classes, teachers asked questions that were of such a low order many learners responses were single words or phrases, often answered as a chorus. This is a common practice of many teachers across the globe: USA (Pimentel & Mc Neill, 2013; Smart & Marshall, 2013), Singapore (Chin, 2007), Brazil and the United Kingdom (Mortimer & Scott, 2003). Smart and Marshall (2013) suggest when teachers plan their lessons, they should consider appropriate high order questions they could ask learners. In this way the quality of their questioning in the classroom will improve. By including higher order questions in their repertoire so teachers will gain a better understanding of what learners already know and can assist them in understanding new science concepts being taught (Chin, 2007)

The preferred move teachers used to respond to learner responses was, ‘evaluation’. Teachers evaluated learner responses either, either explicitly where the teacher responded with ‘That is incorrect’, or ‘You are right’, or implicitly by providing learners with the correct answer. Where learners responded with an incomplete answer, teachers used one of three moves to move the lesson along its planned path. First, they would elaborate on the missing information., second, they would ask the learner to explain their meaning through probing questions or finally ask classmates in a toss back move what their understanding was. In this way the teacher directed the talk in the class. As found in Chin’s (2007), science classes in Singapore, where teachers move away from evaluating learner responses and use a ‘probe’ or ‘toss back’ move, talk in the classroom becomes productive and moves past basic recall.

To maintain order in the class, one teacher, Luke, opted in few instances to either cut-off or ignore learner responses, particularly where learners were attention seeking and or disrupting the lesson.

The dominant pattern of interaction observed in all classes was the triadic IRE, with teachers asking low order questions to steer their lesson on through the required curriculum content. Teachers were using an authoritative discourse. In an authoritative discourse the teacher conveys information, providing learners with facts, statements. Learner responses to teacher questions tend to be single words or phrases (Chin, 2007). This contrasts with a dialogic discourse where the teacher asks open ended questions encouraging learners to explain, argue and debate. Learner responses are typically complete sentences with justifications for statements (Chin, 2007). When teachers provided opportunities to explore what learners already know, discussions were often through the asking of low order questions, resulting in learner responses that were single words or phrases. This was followed by teachers using evaluations, probes and toss backs to get to a sought-after answer.

Mortimer and Scott (2003) contend that each type of discourse has its place in the science classroom. Where the purpose of teaching is to convey science knowledge an authoritative discourse is appropriate as opposed to an inquiry lesson or open-ended problem, which requires learners to explain their reasoning. The purpose of observing baseline lessons was to find out how teachers explore LPK, as Mortimer and Scott would phrase it: 'opening up the problem'. Whilst teachers used whole class discussions, little in depth exploring of LPK was evident in any of the classes. No instances of occurred where teachers planned activities allowing learners to link their existing knowledge to new knowledge being taught. No teacher acknowledged or planned strategies to challenge alternative conceptions learners may have.

4.7 Conclusion

All teachers acknowledged that grade 8 learners come to the science class having made sense of science concepts in some way. Whilst this knowledge may come from various sources, everyday experiences, formal instruction, informal learning or perhaps because a term or concept is already known in their everyday use of language, teachers in this study focused on reminding learners of knowledge gained from formal instruction. This may be knowledge gained from a science class in a previous grade or from a subject whose curriculum covered similar work, for instance the mathematics class.

Whilst the purpose of baseline lessons differed: some teachers introduced a new topic, others concluding a topic, it was Luke the teacher who considered the expert in the Physical Sciences content, the content being taught, who interacted with LPK throughout the lesson. Teachers whose expertise were in the Life Sciences content, and not the Physical Sciences content being taught, interacted with LPK at the start of their lesson. The preferred strategy teacher used by each teacher to explore LPK was whole class discussions. No teacher had planned an activity with the purpose of unpacking learner's existing understanding on the topic that was the focus of the lesson. The only form of interaction with learner's existing knowledge was the teacher asking questions to the whole class. As a result, few learners were given an opportunity to respond to the teacher's questions.

The questions teachers asked were focused on exploring knowledge learners may have gained from formal instruction and everyday experiences. Teachers were aware that in some instance what they thought should have been taught, may not have and that learners forget what they have been taught. A few instances occurred where teachers unpacked the various ways a science term can be interpreted both 'scientifically' and in 'everyday' use. No LPK which may have come from religious beliefs or cultural was explored. This may be linked to the nature and scope of the topics. No teacher planned activities to uncover and challenge possible alternative conceptions learners may have.

The preferred pattern of interaction teachers used when engaging with LPK, was the triadic IRE. Teachers tended to ask low order questions, which resulted in most learner responses being single words or phrases. In many instances, learners would respond as a chorus. The most common teacher move following a learner response was 'evaluation' of the response. Sometimes teachers would explore a response by probing learner understanding further or using a 'toss back' move, where the teacher allowed a second learner to build on a learner response. Occasionally teachers would use a learner response to elaborate on a concept, allowing the lesson to move along its predetermined path.

The socio-cultural theory guiding this research maintains that learners make their meaning in social situations. Ideas are exchanged between the teacher and learners mainly through talk. Teachers tended to stifle the talk when working with LPK as their preferred pattern of interaction was IRE. Here teachers sought specific answers to their low order questions. Learner responses were limited to choral answers or incomplete thoughts. Teachers questions about previous knowledge learners may have, were used to essentially remind learners what they had been previously taught. Whilst the teacher was in a position to guide learners through their ZPD, mediating learning by establishing what learners can achieve on their own and moving them to what they are capable of unassisted, what was observed in all classes was teachers moving their lessons to an end point without really ascertaining what learners already know. The communicative approach teachers opted for when working with LPK was predominantly interactive authoritative.

In the following chapter I describe how teachers changed the way they interacted with LPK when teaching two topics in consecutive years in the hope of linking what learners already know to new concepts being taught. I unpack how including varied sources of LPK into lessons, challenging common alternative conceptions and providing opportunities for learners to explain what they know more fully, influenced d why teachers interacted with LPK the way they did.

Chapter 5

Why do teachers interact with LPK in the ways that they do?

5.1 Introduction

Working effectively with LPK is complex and requires the teacher to make many on the spot decisions as to what their next move will be. To answer my second research sub-question: why teachers interact with LPK the way they do? I will first analyze how teachers interacted with learners as they provided opportunities for learners to make what they already know explicit, over the next four cycles. As discussed in chapter 4, patterns of interaction are concerned with IRE and IRPRE exchanges and are one of the aspects that form part of Mortimer and Scott's analytical framework for analyzing meaning making in classrooms. I unpack the 'I', 'R' and 'P' or 'E' (see chapter 3.10.1.2), components of these interactions, through the various cycles. Having unpacked the patterns of interaction that occurred over the two years, I will consider some of the factors that emerged which facilitated or impeded interaction with LPK, as I wanted to know why teachers interact with LPK the way they do? To answer my second research sub-question, I will answer the following questions:

(a) Having reflected on and planned lessons that include working with LPK, how do teachers interact with learners?
(b) How are learner contributions influenced by the 'I' in the IRE or IRPRE pattern of interaction?
(c) What 'moves' do teachers prefer when working with LPK?
(d) What factors influenced how teachers interacted with LPK?

The previous chapter provided some insights into how teachers interacted with LPK in their baseline lessons. Cycles 2 and 4 were concerned with the topic 'effects of electric current' EoEC in years 1 and 2, respectively. Whereas cycles 3 and 5 were focused on the topic 'light' in years 1 and 2, respectively. By its nature, the topic EoEC provided more opportunities to interact with LPK, as learners came to class having encountered electricity both at home and from formal instruction. The topic light provided fewer opportunities to interact with LPK, as most of the light concepts were considered new to the learners. It is therefore better to compare how teachers interacted with LPK for the same topic over the two years, rather than look at these interactions moving from one cycle into the next. To avoid being repetitive I have decided to answer the first three questions, looking at cycles 2 and 4, broadly. I will then track how teachers taught the same activity: the ‘shadow activity’ from cycles 3 and 5, as this will provide detailed insight into how teachers moved their interactions with LPK from using a predominately non-interactive dialogic communicative approach to including more instances using an interactive dialogic communicative approach. Before delving into how the patterns of interaction, learner contributions and teacher moves, changed over the 2 years, I provide an argument for how I decided which teacher’s lesson on the shadow activity I would use to provide detail for each of the aspects of interactions.

5.2 The ‘Shadow Activity’: *This is stuff you should know by the time you get to school.*

When deciding on the activity I would use to provide rich detail, I needed an activity that was concerned with interacting with LPK, was relatively short and allowed me track changes in the way teachers interacted with LPK over the two years, specifically at changes in the patterns of interactions, learner contributions and teacher moves.

Learners come to class knowing that they have shadows. Luke explained in Reflect 5:

> *This is stuff you should know by the time you even get to school. Primary school, grade 1. Look at here, I've got a shadow, it's following me or it's leading me.*
>
> Luke Reflect 5

In the second year of data collection Luke made the decision not to allow his learners to complete the shadow activity as some learners had become disruptive during his lesson and he did not want the children to leave the classroom. Keeping the learners inside the classroom and listening to him allowed Luke to return order to his class. This means I am not able to compare how Luke’s learners completed the shadow activity from one year to the next.

To make sense of how teachers (Adele, Kate, and myself) interacted with learners during the completion of the ‘shadow activity’, I have analyzed transcripts from lessons and coded data into three aspects: the pattern of interaction (IRE vs IRPRE), learner contributions and teacher moves. To avoid repetition when discussing these aspects and wanting to provide a rich description of what happened I decided to allocate one aspect to each teacher. Since I usually discuss the teachers in the order Adele, Kate, Luke, and myself, I decided to allocate the aspects

I wanted to investigate in the same order. This meant a detailed description of how the patterns of interaction changed is described from what happened in Adele's lessons (see 5.3.2). Changes in learner contributions are unpacked in Kate's lessons (see 5.4.2) and changes in teacher moves are unpacked in from my lessons (see 5.5.3). Luke was excluded as a comparison of what happened in the second year cannot be made.

Having explained how I decided which aspect of teacher's teacher -learner interactions I will unpack from one year to the next, for a particular teacher, when they completed the shadow activity, I continue by presenting results by first showing how the patterns of interactions changed, followed by an analysis of teacher moves and then learner contributions.

5.3 Patterns of Interaction

To answer my second research sub-question, why do teachers interact with LPK the way they do, I needed to first consider how the interactions changed and then attribute reasons to the changes observed. Where teachers interacted with LPK during lessons, I coded the pattern of interaction as either IRE or IRPRE, as I did for baseline lessons (cycle 1). This allows me to answer the first question for research sub-question 2: how do teachers' patterns of interaction change when exploring LPK, having reflected on and planned lessons to include opportunities to work with LPK?

Having coded the patterns of interaction separately for each teacher for all lessons per cycle, I then tallied the totals of all teachers together to get a combined total of the patterns of interaction across the five cycles (see Table 14). Individual teacher's patterns of interaction are given in Table 15 (Adele), Table 16 (Kate), Table 17 (Luke) and Table 18 (Jenny). Before discussing how individual teachers' patterns of interaction varied across the cycles, I will unpack the combined patterns of interactions for all teachers.

When planning the lessons and activities for the content EoEC (plan 2), Luke took the lead as he was considered the expert, being the school's Electrical Technology teacher. Working with Luke's suggestions we developed lessons that would include various types of LPK, including opportunities for learners to possibly express known alternative conceptions. For example, Luke made us aware that many learners will state that light and sound are effects of an electric current. Having prepared what needed to be taught and developed activities that would encourage learners to tap into their existing knowledge, the teachers taught their planned lessons.

Comparing the number of interactions that occurred when teachers interacted with LPK from lessons in cycle 1 (baseline practices) to those in cycle 2, there was a decrease in the total number of IRE and IRPRE patterns of interaction: 152 interactions were coded in cycle 1 and only 137 in cycle 2 (see Table 1).

Table 14: Combined Teachers: Patterns of Interaction

	Cycle	IRE	IRPRE	Total
Year 1	1	92	60	152
	2	79	58	137
	3	125	80	205
Year 2	4	172	198	370
	5	152	108	260

The preferred pattern of interaction in cycles 1 and 2 was the triadic IRE. During Plan 4 teachers agreed that learners struggled to understand the reasons why they were doing the activity and were more focused on completing the activity. The 'prompt' and 'toss back' teacher move was discussed as these two moves not only allow teachers to gain deeper insights into learner thinking and but also guide learners in their understanding of how activities relate to concepts being taught. Activities were revised and re-ordered when planning to teach EoEC in year 2. The total number of interactions more than doubled when comparing cycle 2 (137 interactions) and 4 (370 interactions) (see Table 14). Slightly more IRPRE interactions occurred (198) compared to the previously favoured IRE interaction (172) during cycle 4.

Whilst the number of interactions increased from year 1 to year 2 for the light content: cycle 3: 205 interactions compared to 260 interactions in cycle 5, the preferred interaction in both years was the IRE pattern (see Table 14). I will explore reasons for this when I discuss the patterns of interaction when I discuss why both Luke and I opted to use the IREs pattern of interaction in our lessons.

5.3.1 Adele and Kate: Patterns of Interaction

I have chosen to discuss Adele and Kate's patterns of interaction together as they are both inexperienced Life Sciences teachers who are teaching the Physics component of the Natural Science curriculum. Whereas Luke and I are both experienced teachers.

Comparing the total number of interactions from cycle 1 (baseline lesson) to cycle 2 (EoEC year1), there was an increase in the number of interactions (see Table 15 and Table 16), for both Adele and Kate. This may be because teachers were made aware of Mortimer and Scott's framework for analysing meaning making in classrooms, and attention was drawn to the difference between IRE and IRPRE patterns of interaction, when reflecting on baseline lessons (reflect 1).

Table 15 Adele: Patterns of Interaction

	Cycle	IRE	IRPRE	Total
Year 1	1	25	15	40
	2	18	18	36
	3	25	19	44
Year 2	4	36	55	91
	5	74	35	109

When comparing the patterns of interactions from the EoEC lessons over the two years, i.e. cycle 2 with cycle 4: the increase in the number of interactions was almost threefold for Adele and doubled for Kate. Teachers had reflected on using various communicative approaches when interacting with LPK in reflect 2. During plan 4 much time had been spent exploring alternative conceptions learners may have and activities were revised to encourage teachers to explore existing learner understandings on concepts, before new concepts were taught.

In cycle 4, 60% of Adele's patterns of interaction were coded as IRPRE, compared to 50% in cycle 2. In both years Kate's preferred pattern of interaction was the IRE, 59% of interactions, (cycle 2) and 54% of interactions (cycle 4). The number of both IRE and IRPRE interactions increased in cycle 4. (See Table 16).

Table 16 Kate: Patterns of Interaction

	Cycle	IRE	IRPRE	Total
Year 1	1	12	9	21
	2	29	20	49
	3	26	14	40
Year 2	4	53	46	99
	5	31	27	58

A similar trend was found for Kate when comparing the patterns of interaction from the 'light' lessons: 65% of the interactions in year 1 (cycle 3) were coded IRE compared to 54% in year 2 (cycle 5).

5.3.2 Patterns of Interaction: 'Shadow activity' - Adele

In her lesson in the first year of the project Adele did not create any opportunities to explore what learners knew about their shadows, before sending them out of the classroom to complete the activity. The excerpt below is from year 1 when the shadow content was taught.

Turn 1	Adele	*Thank you Grade 8s shoosh. Ok, there is no reason to walk around right now. You are going to go to Activity 4. You are going to please complete activity 4 in the next 10 minutes. You are going to go outside onto the A field. Right, which is the field right behind us. You guys are going to draw your friend and their shadow in that space provided. Now for Mrs Woolway we need to record this. Excuse me. So, you guys are going to be, you know in those groups of three you guys were in on Monday. Do you remember those groups of three?*
Turn 2	Chorus	*Yes, No.*
Turn 3	Adele	*It's the group you're sitting in.*
Turn 4	Ayanda	*Oh.*
Turn 5	Adele	*You guys are going to go in groups of three. One person records while the other person draws, and then next person needs to stand there so that they can get you and your shadow. Now I strongly suggest that you make funny shapes with your body. And then you get funny shadows. Ok. So, you need to draw the person and their shadow. On this piece of paper right here. You need to follow the instruction, so you need to show me where the sun's rays are going and all the rest of it. On the diagram. Everybody understand? Ok. Go to the A field. Go, go go.*

Adele: Shadow Activity, Cycle 3

The only interaction that occurred was at the end of Turn 1, where Adele asks the learners if they remember what group they are in. In turn 5, Adele gives some direction as to what the learners need to do: draw a shadow of the person and show where the sun's rays are. Once the learners leave the class to complete the activity, Adele did not interact with them at all. Rather she chose to come over to where I was observing the lesson and talk to me. Once the learners had returned to the class having completed the activity, Adele allowed for a short report back consisting of 10 turns, see excerpt below:

Turn 105	Adele	*... Ok, so you guys should have drawn something similar to this with your friend standing there. Where would her shadow be? At the back of her?*	I
Turn 106	Chorus	*No*	R

Turn 107	Adele	*In the front of her?*	P
Turn 108	Chorus	*Yes.*	R
Turn 109	Adele	*Why?*	P
Turn 110	Rachelle	*Because the sun is shining at her back.*	R
Turn 111	Adele	*Because the sun's rays should have been hitting at the back.*	E
		And what is she? Is she opaque, transparent, translucent?	I
Turn 112	Chorus	*Opaque*	R
Turn 113	Adele	*Opaque.*	E
		So, does light go through her?	I
Turn 114	Chorus	*No*	R
Turn 115	Adele	*So light hits at the back and then her shadow should be in the front, hey. Do you all have all your sun diagrams on there? Sun rays included. You all have that?*	E

Adele Shadow Activity, Cycle 3

In this excerpt Adele uses both IRE and IRPRE patterns of interaction to provide learners with an opportunity to speak. Of the three interactions two were coded IRE and one IRPRE. Four of the five learner responses were chorus answers.

In year 2, there are 28 turns from the time Adele mentions the shadow activity, to the time learners leave the class to complete the activity. This compares to 5 turns in year 1. In the excerpt below from the lesson in year 2, Adele starts by placing emphasis on the position of the shadow of an opaque object relative to the light source. Her instructions in turn 5 are explicit as to what she requires the learners to do: draw a 'scientific' diagram of a friend and their shadow, observing the position of the sun and the shadow.

Turn 5 Adele *Good. You're required to work in pairs with one exception, because Naledi is absent. I know it is so sad. You are going to have to draw a diagram of your friend and his or her shadow. You need to pay attention to: where is the sun? Ok. Where the shadow falls. You then need to use your diagram rules that you've been taught at the beginning of the year and you can draw your friend and his or her shadow, in the diagram box below. You have to add light rays from the sun, to show how the shadow is formed. Ok. So, there's a picture of what you guys have, right? Everybody see that?*

Adele Shadow Activity: Cycle 5

Adele then moves on to explore where shadows fall by working through an activity she had designed on her own and was not part of the lesson plan. In this activity Adele had prepared a power point slide where she where she interrogates learner understandings by including some alternative conceptions: for example, having the shadow include detail of the person and not represented as a silhouette, as well as placing the shadow in various positions relative to the sun. The transcript below is from this interaction.

Turn 7	Adele	*Ok, now I had to cut out the little girl and I've put her in, with the shadow. Can you see that? Ok. Now it says you must add light rays. So, I added light rays. Is that right?*	**I**
Turn 8	Chorus	*No*	R
Turn 9	Adele	*What's wrong?*	P
Turn 10	Lesedi	*No, Ma'am, the place where the person and the shadow is.*	R
Turn 11	Adele	*So, you're saying there's something wrong with where my shadow is?*	P
Turn 12	Rea	*Yes.*	R
Turn 13	Adele	*Where's my shadow supposed to be, Nomi? Rea, sorry, Rea.*	P
Turn 14	Rea	*Because of the light goes.*	R
Turn 15	Adele	*Behind the girl?*	P
Turn 16	Rea	*Ma'am like on the side? So, is it supposed to go there?*	R
Turn 17	Chorus	*Yes.*	R
Turn 18	Adele	*Ah.*	E
		What else is wrong with my shadow? Yes?	**I**
Turn 19	Mpumi	*The head is missing.*	R
Turn 20	Adele	*The head is missing. That unfortunately I could not change.*	E
Turn 21	Anele	*Ma'am, you see the shadow, it shows what she's wearing.*	R
Turn 22	Adele	*Ah, the shadow is showing her in the shoes and yes. He is completely right. The shadows showing, what? Is your shadow going to show you what your friend's are wearing?*	P
Turn 23	Chorus	*No*	R

Adele Shadow Activity Cycle 5

Adele initiated interactions, by asking learners if the shadow's position is correct in Turn 7 'Is that right?' What follows is a back and forth with learners, where Adele uses prompts and toss backs for learners (Lesedi and Rea) to explain where the shadow should be cast. This interaction was coded IRPRE as Adele probed learner meaning by asking: 'What's wrong?' (turn 9), 'where is my shadow supposed to be? (turn 13) and 'behind the girl?' (turn 15). This contrasts to the next interaction where Mpumi states that 'the head is missing' (Turn 19), from the shadow, that was coded as an IRE, as in turn 20 Adele agrees 'The head is missing.'

However, Adele could not include the head of the shadow on the slide, as there was not enough space.

Whilst learners were outside completing the activity Adele moved between the learners with a total of 133 turns taking place, this compares to Year 1 where Adele did not interact with her learners at all while they completed the shadow activity. However, in the second year Adele did not have a 'report back' as she did in the first year once learners had completed the activity and returned to class. In the second year the bell rang signalling the end of the lesson as learners returned to class. In the following lesson Adele moved forward with new content and did not refer to the shadow activity.

The opportunities Adele gave learners to speak in class during the 'shadow activity' was greater in the second year compared to the first. In the first year only 5 turns occurred from the start of the 'shadow activity', to the time learners left the class to draw their shadows. This compared to 28 turns in the second year. Further, in the first year Adele did not interact with the learners whilst they were outside. In the second year Adele walked amongst the learners with 133 turns occurring. However, Adele provided an opportunity for a report back in the first year where 10 turns occurred. No report back occurred in the second year.

Even though there was an increase in the number of IRPRE patterns of interaction in cycle 5, Adele's preferred pattern of interaction remained the triadic IRE (see Table 15).

5.3.3 Luke and Jenny: Patterns of Interaction

Comparing the patterns of interaction in Luke's baseline lesson (cycle 1) to EoEC lessons in year 1 (cycle 2): there was a decline in the total number of interactions, even though we had planned activities in the hope of encouraging more IRPRE patterns of interaction (see Table 17). Whilst the number of interactions in my class had increased from 19 (cycle 1) to 29 (cycle 2), the increase was not the same increase as happened in Adele and Kate's lessons. A possible reason for this may be in the restless behaviour of learners. Both Luke and my classes included learners, who were easily distracted and tended to disrupt those around them. To maintain order within the class, it was easier to move the lesson along its predetermined path once learners started going off task, rather than ask learners to explain their understanding. This is an extract from my reflection notes following one of my EoEC lessons in Year 1.

Learners struggle to settle down when one person talks, and this becomes very frustrating.

Jenny Year 1

Comparing the number of interactions from cycle 2 to cycle 4: there was an increase for Luke from 23 interactions to 66 (see Table 17). The number of interactions also increased in my EoEC lessons, from 29 interactions in year 1 to 114 interactions in year 2 (see Table 18).

Table 17 Luke: Patterns of Interaction

	Cycle	IRE	IRPRE	Total
Year 1	1	44	28	72
	2	18	5	23
	3	17	6	23
Year 2	4	41	25	66
	5	24	15	39

There was an increase in the number of interactions from year 1 (cycle 3) to year 2 (cycle 5) for the 'light' content for both Luke and I. In cycle 3, 26% of Luke's patterns of interactions were coded as IRPRE and this increased to 39% in cycle5 (see Table 17). 42% of the interactions that occurred during cycle 3 in my lessons were coded as IRPRE, compared to 57% during cycle 5.

Table 18 Jenny: Patterns of Interaction

	Cycle	IRE	IRPRE	Total
Year 1	1	11	8	19
	2	14	15	29
	3	57	41	98
Year 2	4	42	72	114
	5	23	31	54

In Luke's class in year 2 there was a small group of non-participant girl learners who were ill-disciplined. The extract below is an example of an incident where the girls annoyed Luke. Having completed the introductory activity for the EoEC content, Luke was hoping for groups to report back to the class. As Luke was walking amongst the learners, he noticed the girls did not have the notes. When Luke asked the girls where their notes were, the learners replied that they had been 'stolen'. Irritated by their reply, Luke walked to the front of the class, and went through the activity by reading each question followed by the answer.

Turn 43	Luke	*Really? So, somebody stole it, right? Right, thank you. You have now discussed the answers I am going to quickly run through the model answers. You need to see how close you were to getting them correct, or close to it. You don't have to record me. Right the first one is, what is the purpose of electric wire. We do not have time to ask each individual group to give answers. I am just going to do it so that we can mark it. Right, a purpose of conducting wire, of electric wire is to conduct electricity or allow electrons to flow through the circuit. Or allow the flow of current. What is insulation? Insulation is plastic, or some other form of covering that does not conduct electricity. And we normally put it around the wires so that we don't get short circuits or get shocked.*

Luke EoEC Lesson Cycle 4

The girls frustrated Luke and the easiest way to retain order in the class was to abandon any form of interaction with the learners and revert to a non-interactive authoritative communicative approach.

5.3.4 Conclusion: Patterns of Interaction

Working collaboratively reflecting and planning lessons resulted in teachers interacting with learners using both IRE and IRPRE pattern of interaction. The two inexperienced teachers increased the number of interactions with learners from year to the next year when the same content was taught. There was an increase in both types of interactions for the inexperienced teachers. Whilst there was an increase in the number of interactions from one year to the next for both content areas in Luke's classes, the increase was not as great as what occurred in Adele and Kate's class. It was only for the EoEC content, where the number of interactions in my class increased from one year to the next. In the second year for the light content there was a decrease in the number of interactions compared to the first year. Where learners became restless and disruptive teachers interacted with a learner using the IRE , so as to maintain order and move through the content.

5.4 Learner Contributions

To answer my second question for research sub-question 2: How are learner contributions influenced by the 'I' in IRE and IRPRE patterns of interactions, learner contributions, were coded using the coding scheme described by Pimentel and Mc Neill (2013) (see 3.10.1).

Findings from baseline practices before the intervention showed that learner responses were predominantly single words or phrases (level 1), in reply to the low order questions that were asked by all the teachers (see Table 19). Learners often responded in a single word chorus, ‘yes’ or ‘no’ because of the low order questioning (see 4.5.1). Few instances occurred where learners responded giving reasons for their complete thoughts (level 3). Whilst teachers included LPK in their lessons, they did not require learners to explain their meaning.

In cycle 2 teachers planned to work deliberately with different sources of LPK and had developed activities to encourage learners to explain what they already knew. As a result the number of learner responses coded, for all teachers increased from 272 learner contributions in cycle 1, to 327 in cycle 2 (see Table 19).

Table 19 Combined Teacher: Learner Contributions

	Cycle	0	1	2	3	TOTAL
Year 1	1	24	168	61	19	272
	2	39	188	82	18	327
	3	23	266	75	5	369
Year 2	4	207	566	188	42	1003
	5	34	406	124	30	594

Whilst learner contributions coded level 3 remained much the same from cycle 1 to cycle 2, there was an increase in both the number of level 1 and level 2 contributions comparing the baseline and cycle 2 More opportunities were created for learners to make their voice heard as teachers explored LPK.

When planning lessons for cycle 3 teachers prepared activities to work with LPK in various ways. The number of learner contributions, increased from cycle 2 (327 contributions) to cycle 3 (367 contributions, see Table 19). Learners continued to respond to teachers’ questions using mostly single words or phrases (level 1), with few contributions being complete thoughts (level 2) and even fewer complete thoughts with reasons (level 3) (see Table 19).

There was almost a threefold increase in the number of learner contributions comparing cycle 3 to cycle 4. When reflecting on the ‘light’ lessons, during reflect 3 teachers said that learners struggled to understand why they were completing the activities. Teachers were introduced to the ‘prompt’ and ‘toss back’ move during plan 4. As a result of the greater number of prompts and toss backs teachers used during lessons in cycle 4, the number of learner utterances increased. Teacher moves will be discussed in more detail in the next section (5.5).

The highest number of contributions by learners happened in cycle 4 with 1003 (see Table 19). As a result of the updated activities and how the discussions were facilitated more opportunities were created for learners to speak. During this cycle more than half of the learner contributions were still single words or phrases. However, the number of level 2 and level 3 responses doubled compared to when the same content was taught the previous year (cycle 2), (see Table 19).

In cycle 4 teachers started to prompt learners to explain their thinking. Sometimes a learner did not know how to answer the question or needed the question rephrased. The learner would respond with 'Pardon?' or 'Ma'am?' This is the reason there is an increase in level 0 learner contributions. The teacher would then either ask the question again or rephrase it, with the learner responding, often using an incomplete thought (level 1). To encourage the learner to explain their meaning the teacher would either prompt the learner for a reason or would toss the response back to the class where a different learner would respond. The extract below, taken from one of my EoEC lessons in year 2 (cycle 4), and is an example, where a prompt was used to encourage Joshua to explain what he meant in more detail.

			Learner contribution Level
Turn 329	Jenny	*The third one is the magnetic effect. Joshua, what did we do to show that electric current causes a magnetic effect? How do we know that?*	
Turn 330	Joshua	*Ma'am?*	0
Turn 331	Jenny	*We did two things.*	
Turn 332	Joshua	*Yes Ma'am.*	0
Turn 333	Jenny	*What was one?*	
Turn 334	Joshua	*Ma'am can I say anyone.*	1
Turn 335	Jenny	*Anyone.*	
Turn 336	Joshua	*Ma'am we said Ma'am it caused the nail, the nail to pick up metal, metal objects.*	2

Jenny EoEC Lesson Cycle 4

The most frequent learner contribution was coded as level 1 in cycle 4, as it was for the previous cycles. However, the number of learner contributions that were complete thoughts (level 2) and those that had thoughts with reasoning (level 3) increased, when comparing lessons on the same content (cycle 2 and cycle 4) year on year.

There was a decrease in learner contributions, comparing cycle 5 with cycle 4 (see Table 19) This can be explained in terms of the content of the lesson. Learners come to class with some knowledge of electricity (Cycle 4) from their everyday experiences and formal instruction.

Fewer opportunities to explore learner understandings of light (Cycle5) occur, as this content has not been taught in previous grades and is not something learners may ponder on in their everyday experiences.

It is therefore useful to compare learner contribution when the same content was taught over the two years. Not only was there an increase in the number of learner contributions, 327 in cycle 3 to 594 in cycle 5, but there was also an increase in the number of high level learner contributions, with many more level 3 learner contributions occurring in cycle 5: This is likely due to a change in the level at which teachers asked questions, as during plan 5 teachers prepared high order questions for their lessons.

Having looked at how the overall learner contributions changed over the five cycles I will now discuss the level of learner contributions for each teacher in more detail. I will provide a detail description using the 'shadow activity' when discussing Kate's results. Once again I have grouped teachers based on their experience together: Adele and Kate (inexperienced teachers) and Luke and myself (experienced teachers).

5.4.1 Adele and Kate: Learner Contributions

In year 1 the number of learner contributions increased with each cycle in Adele's lessons; 76 contributions in cycle 1, 86 in cycle 2 and 96 in cycle 3 (see
Table 20). The same did not occur in Kate's lessons: there was an increase from 36 learner contributions in cycle 1, to 113 learner contributions in cycle 2 (see Table 21), this was followed by a decrease in the number of learner contributions in cycle 3.

Table 20 Adele: Learner Contributions

	Cycle	**0**	**1**	**2**	**3**	**TOTAL**
Year 1	1	4	53	13	6	76
	2	5	60	17	4	86
	3	6	70	17	3	96
Year 2	4	67	158	59	25	339
	5	13	171	49	14	247

However, when comparing the number of learner contributions for the same content taught year on year in Kate's class, not only did the number of learner contributions increase, so did the level at which learners were responding. For both Adele and Kate, the highest number of learner contributions occurred in cycle 4.

Table 21 Kate: Learner Contributions

	Cycle	0	1	2	3	TOTAL
Year 1	1	1	22	9	4	36
	2	20	58	27	8	113
	3	1	44	18	2	65
Year 2	4	74	198	68	10	350
	5	10	79	28	6	123

I will explore learner contributions in depth by comparing learner contributions from the 'shadow activity' in year 1 and year 2 from Kate's lessons.

5.4.2 Learner contributions: 'Shadow activity' - Kate

In her first year Kate introduced shadows by asking learners if they are able to see through various items and objects found in the class. The excerpt below is when this discussion occurred.

Turn 271	Kate	*No. Can you see through your chair?*	I
Turn 272	Chorus	*No.*	R
Turn 273	Kate	*Can you see through your hand?*	I
Turn 274	Chorus	*No.*	R
Turn 275	Kate	*No.*	E
		Could light able to pass through the desk?	I
Turn 276	Chorus	*No.*	R
Turn 277	Kate	*No.*	E
		So, what is it going to create at the bottom?	I
Turn 278	Chorus	*Shadow*	R
Turn 279	Kate	*A shadow, right. Ok. So, what happens is opaque objects do not allow any sort of light to travel through them. Ok. The light actually bounces off them and we actually… a little bit later in this section we go on to how we see the different colours that we see. So, opaque objects don't allow any light to bounce through them. In fact, they create shadows when light is shone on them. What I would like you guys to do is the next activity. The quicker we do this the quicker we can outside and do a little bit of drawing.*	E

Kate Shadow Activity Cycle 3

Kate asked learners low order yes/no questions (Turns 271, 273 and 275) as to whether various objects allow light to pass through them. All the interactions were coded IRE and learners responded in a chorus with a single word: ‘no’. This was coded as a level 1 learner contribution. Kate then explained the ‘shadow activity’ to the learners in turn 341

> *You are gonna get a partner. You and your friend are going to draw each other and how your shadow falls. You are gonna go stand. We will stand by the tree. You guys are going to stand in the sun. Your partner is going to draw you. And you are going to draw your partner ok. So, you are going to draw each other and you can draw stick men. You don't have to worry about your artistic skills here. You can draw stick men, and then you just show on your drawing where the shadow is going to be. Do you understand?*

The only other interaction Kate had with a learner whilst outside was when she spoke to Amanda explaining how to complete the activity, see turn 374 in the excerpt below.

Turn 374	Kate	*The stick person and then the shadow coming. You, draw your person. And then the shadow coming from them.*
Turn 375	Amanda	*The person standing in the front, their shadows are in the back.*

Amanda responds in a complete sentence and the utterance was coded as a level 2 learner contribution. Having completed the activity learners returned to class and Kate chose not to have a report back session.

In year 2 (cycle 5), the first time Kate makes mention of a shadow was when she explained the ‘shadow activity’, see the excerpt below.

Turn 184	Kate	*Ok. So, what we are going to do now is, we are going to go outside. And we are going to have a look at our shadows. It is activity 4 in your notes. Um, on page 5. For this activity, you will go outside, you're required to work in pairs. Draw a diagram of your friend and his or her shadow. You don't actually need to draw your friend with her eyes and ears and their proportion. Just draw a stick man, please. Ok, it doesn't have to be, it doesn't have to be artistically beautiful. I know some of you are not artistically gifted. Ok, er, you need to pay attention to number one, where the sun is. So, look at where the sun is around you. When we go outside we will have look at where the sun is. And we will have a look at where your shadow falls, in relation to the sun. And then you need to have a look on this page. Where the sun is on this page. And you need to figure out where your shadow would be, on the page. Er, use diagram rules, that, that you were taught at the beginning of the year. You can draw your friend and his or her shadow in the diagram box below. Add*

light rays from the sun to show how the shadow is formed. Ok, so you remember when we did the candle, you were showing me the arrows. You are going to do the same thing now. You need a pencil, you probably need a book to press on and you need your notes. Otherwise everything else can stay in class.

Kate Shadow Activity Cycle 5

Whilst learners were completing the activity outside the classroom, Kate walked around asking the groups questions, making learners aware of errors in their diagrams by having them observe their shadows more carefully. On returning to class Kate allowed for a lot of back-and-forth discussion with the learners. Given below is of part of the discussion where Kate asks learners to explain why shadows form.

			Learner Contribution Code
Turn 331	Kate	*Ok, the general idea, is, is right. So, why exactly is the shadow over here? What causes this to happen, Rumaana? Sorry guys, Bongi. When you speak everyone else listens. Show everyone else the same courtesy.*	
Turn 332	Bongi	*Yes, Ma'am.*	
Turn 333	Rumaana	*When the sun is like over there, Ma'am, and then, you're standing like there. This one. The rays will become this way. And then what's this, and make a shadow on here.*	3
Turn 334	Kate	*Ok, but what causes the shadow? Rumaana is right. So, for the rays are coming this way. What causes the shadow? Tebogo?*	
Turn 335	Tebogo	*Ma'am the human body.*	1
Turn 336	Kate	*What about the human body?*	
Turn 337	Tebogo	*It is not transparent, so it blocks...*	1
Turn 338	Kate	*The word for it?*	
Turn 339	Shaznay	*Opaque.*	1
Turn 340	Tebogo	*Opaque.*	1

Turn 341	Kate	*Opaque. Ok. In this case the human body is opaque. And because the human body is opaque what does that mean?*	
Turn 342	Tema	*The light.*	1
Turn 343	Sihle	*It won't shine through.*	1
Turn 344	Kate	*What won't shine through?*	
Turn 345	Sihle	*The light.*	1
Turn 346	Kate	*The light won't shine through. So, if you think about it, what is, is your shadow dark, light? How would you describe it?*	
Turn 347	Kendal	*Dark.*	1
Turn 348	Kate	*It's dark. Why do you think it's dark?*	
Turn 349	Kendal	*Cause it's*	0
Turn 350	Sihle	*Ma'am cause it's a reflection of your body. Cause you can't see clearly to actually.*	2
Turn 351	Kate	*Ok. You're right except for that one word that you used there: reflection. It's not really a reflection of your body. What is, William, what were you going to say?*	
Turn 352	William	*I was saying.*	0
Turn 353	Kate	*Ok, say what you were going to say.*	
Turn 354	William	*Ma'am, I was saying, the human body is opaque, Ma'am. No light goes through, Ma'am. And so, it blocks light. Yes Ma'am, an outline of the human body.*	3

Kate Shadow Activity Cycle 5

Kate's questions in year 2 have moved away from yes, no low order questions to those that require learners to respond in full sentences. This was because Kate's 'I' move had changed to a more cognitively demanding form. For instance, in Turn 331 Kate asks: *Why exactly is the shadow over here? What causes this to happen?* Rumaana provides an answer consisting of 3 sentences. First, she refers to the position of the sun: *When the sun is like over there.* Rumaana then links the position of the person, to the direction of the light rays as to where the shadow is cast. T*hen, you're standing like there. This one. The rays will become this way. And then what's this, and make a shadow on here* In turn 334 Kate acknowledges Rumaana's answer but seeks a more in-depth answer: *What causes the shadow?* Tebogo gives a phrase as a reply in turn 335 *Ma'am the human body.* This response was coded a level 1. Kate then prompts Tebogo to provide a more complete answer in turn 335: *What about the human body?* Tebogo replies still with a level 1 learner contribution: *It is not transparent, so it blocks…* In turn 341 Kate asks *And because the human body is opaque what does that mean?* This encourages two learners Tema and Sihle to respond. However, both respond using a phrase: Tema: *The light* (Turn 342) Sihle: *It won't shine through*, both utterances coded a level 1. Still wanting learners to explain their meaning Kate asks: *How would you describe it?* (Turn 346) and then *Why do you think it's dark?* (Turn 348). This results in Sihle now responding in a full sentence: . *Ma'am cause it's a reflection of your body. Cause you can't see clearly to actually* (Turn 350). In so doing Sihle exposes an alternative conception regarding use of the term 'reflection'. Having been made aware of the incorrect use of the term, Kate then uses a toss back move, asking William to explain his understanding. William's response consists of three sentences, where he explains his understanding: First he makes a statement: *the human body is opaque*. This is followed by his reasoning, which he states twice: *No light goes through* and *and so, it blocks light.* This is the reason why a shadow forms *an outline of the human body.*

In the second year (cycle 5) when exploring learner understanding of how shadows are cast: Kate interacted with learners more by asking many questions whilst the learners were completing the activity and during the report back in class. Kate used probes and toss back moves to have learners explain their meaning. This resulted in more learner contributions compared to the first year. Further, the questions Kate asked in the second year were higher order, for instance; How would you describe it? Why do you think it's dark? What causes the shadow? This encouraged learners to respond not only in full sentences but also to provide reasons for their understandings. Having learners make their understanding explicit allows teachers to interact with this knowledge in a meaningful way.

5.4.3 Luke and Jenny: Learner Contributions

The number of learner contributions in Luke's class decreased from one cycle to the next in year 1, with 126 learner contributions occurring in cycle 1 (see Table 22), 46 learner contributions in cycle 2 and 31 in cycle 3. This did not occur in my classes: there was an increase in learner contributions from one cycle to the next: 34 learner contributions (cycle 1), 82 learner contributions in cycle 2 increasing to 177 learner contributions in cycle 3, (see Table 23).

Table 22 Luke: Learner Contributions

	Cycle	0	1	2	3	TOTAL
Year 1	1	17	67	34	8	126
	2	8	28	9	1	46
	3	1	23	7	0	31
Year 2	4	41	94	13	0	148
	5	5	65	9	5	84

An explanation for a decrease in the number of learner contributions coded in Luke's class, can be linked to a decrease in both the number of interactions and the number of IRPRE interactions coded for him in cycle 2 (see Table 17). As Luke was prompting and tossing back less, the number of learner contributions also decreased. Whilst the number of interactions was the same from cycle 2 to cycle 3, the number of learners Luke allowed to contribute in IRPRE chains was less in cycle 3 compared to cycle 2 and this was this reason for the decline in learner contributions in cycle 3. There was also a decline in the number of level 2 and 3 learner contributions comparing cycles 1, 2 and 3. Luke opted to move the lesson he had planned on its predetermined path and wanted to avoid giving learners a space to go off task, as such he did not provide much opportunity for learners to make their prior knowledge explicit.

In his final interview Luke explained his frustration of learners either going off task or not participating when given an opportunity to talk.

Turn 58	Luke	*Once you give them an opportunity to start talking about something, this person will come up with an intelligent part of the conversation and this person will talk about the days of the year. And what's happening over the weekend. I am not, I am not.*
Turn 59	Jenny	*I am just listening, that's fine.*
Turn 69	Luke	*I am not the listening type of person. I would much rather stand up here and chalk and talk and overhead and.*

Luke final Interview Year 2

However, when comparing learner contributions with cycles concerned with the same content there was an increase in the number of learner contributions. For instance, 148 learner contributions occurred in cycle 4 compared to 46 learner contributions in cycle 2 and 84 learner contributions in cycle 5 compared to 31 learner contributions in cycle 3 (see Table 22). There was also an increase in the number of level 2 contributions comparing like content areas over the two years. Whilst no level 3 learner contributions occurred in cycle 4, 5 were coded in cycle 5.

The number of learner contributions that occurred in my class increased through the cycles in the first year of the study. However, there was a decline in the number of learner contributions when comparing cycle 3 to cycle 5: 177 learner contributions in cycle 3 compared to 140 in cycle 5 (see Table 23).

Table 23 Jenny: Learner Contributions

	Cycle	0	1	2	3	TOTAL
Year 1	1	2	26	5	1	34
	2	6	42	29	5	82
	3	15	129	33	0	177
Year 2	4	25	116	48	7	196
	5	6	91	38	5	140

When comparing like content areas in year 1 with year 2 (Viz cycles 2 and 4 together and cycles 3 and 5 together) there was an increase in the number of learner contributions coded level 2 and level 3 in year 2. For instance, in cycle 4, 48 learner contributions were coded level 2 compared with 29 learner contributions in cycle 2 and 4 respectively. Seven learner contributions coded level 3 compared to 5 learner contributions coded at level 3 in cycles 2 and 4 respectively. For the light lessons, no learner contributions were coded as level 3 during cycle 3 and this increased to 5 learner contributions. This result is likely due to an increase in prompts and toss backs used as well as planning for the use of higher order questions in cycle 5.

5.4.4 Conclusion: Learner Contributions

In all cycles, teachers had instances where they interacted with LPK, by asking questions. Initially learner responses were predominantly single words or phrases. When more opportunities were created to explore LPK, the number of learner responses increased, but were still predominantly level 1 learner contributions. The third cycle focussed on moving teaching practices from being predominantly IRE patterns of interaction to including IRPRE patterns of interaction. Once again, the number of learner contributions increased for all teachers during cycle 3, except Luke, who opted to use a non-interactive authoritative communicative approach at times, as some learners were disruptive, and he wanted to maintain order in the class.

When planning lessons for cycle 4, teachers focussed on creating opportunities to have learners explain what they know by making use of prompts and toss backs. This resulted in more learner contributions being coded, and the most level 3 learner contributions occurred during this cycle. Teachers were now starting to interact with LPK at a deeper level, having learners explain their meaning. When teachers considered higher order questions that they could ask learners in cycle 5, there was an increase in the level at which learners contributed, comparing cycles from the same content area. I continue the results, to show how teacher moves changed over the five cycles.

5.5 Teacher Moves: 'E' and 'P' in IRE and IRPRE

How a teacher responds to a learner contribution decides the pattern of interaction that occurs, IRE vs IRPRE, by either shutting down or opening up interactions. I used seven categories to code 'teacher moves': four defined by Pimentel and Mc Neill (2013) namely: cut off, probe, toss back and evaluation and added a further three: evaluation, ignore and procedural (see section 3.10.2)

The preferred teacher move by all teachers in cycle 1 was to evaluate learner responses, (see Table 24). This follows from the finding that the predominant pattern of interaction in cycle 1 was IRE. The second most favoured move in cycle 1 was the 'toss back'. Occasionally teachers included other moves (cut offs, probes and elaborations) as part of their repertoire. Only two instances occurred where teachers ignored a learner's response. Teacher moves during baseline lessons were discussed in detail in the previous chapter. Table 24 below summarises the types of teachers moves that occurred during the various cycles.

Table 24 Combined Teacher Moves

	Cycle	Ignore	Cut off	Toss Back	Probe	Elaborate	Evaluate	Procedural	Total
Year 1	1	2	11	60	24	31	80	0	208
	2	3	2	69	75	41	70	97	357
	3	1	2	57	77	29	87	1	254
Year 2	4	14	6	388	329	106	161	322	1326
	5	0	0	64	174	58	118	0	414

Due to the nature of the activities that were planned, the preferred teacher move during cycle 2 lessons was procedural, where explanations on what was required to complete activities was given. Being aware that the purpose of the project was to explore LPK, teachers started to include more toss back and probe moves. Few instances occurred where teachers ignored or cut off a learner response (see Table 24).

There was a threefold increase in the number of teacher moves coded, when comparing 'teacher moves' with lessons taught on the same content in year 2 (cycle 4). Probes and toss backs counted for more than half the teacher moves. Whilst teachers still evaluated answers this move occurred less frequently. Procedural moves were abundant as teachers needed to clarify what should be done to complete activities. When learners became disruptive by going off task teachers opted to 'ignore' inappropriate responses. This is the main reason for the 'ignore' move unless the teacher did not hear a learner's response.

Due to the content allowing for less interaction with LPK, the light lessons resulted in fewer teacher moves compared to the EoEC lessons. However, year on year there was an increase in teacher moves when comparing lessons from cycle 3 with those of cycle 5. Whereas in cycle 3 the preferred teacher move was 'evaluate' this was not the case in cycle 5. During cycle 5 teachers probed learner's meaning, rather than simply evaluating a response. Few toss back moves were coded in cycle 5. I will now unpack how the teacher moves changed over the cycles for the various teachers. Once again, I have grouped the two inexperienced teachers, (Adele and Kate) together and the two experienced teachers (Luke and myself) together.

5.5.1 Adele and Kate: Teacher Moves

There was an increase in the number of teacher's moves in both Adele and Kate's EoEC lessons in cycle 2 compared to baseline lessons. This increase was almost double in Adele's lessons (see Table 25) and almost four-fold increase in Kate's lesson (see Table 26).

Table 25 Adele: Teacher Moves

	Cycle	Ignore	Cut off	Toss Back	Probe	Elaborate	Evaluate	Procedural	Total
Year 1	1		1	18	11	6	20		56
	2			13	28	13	15	15	84
	3			23	21	5	19		68
Year 2	4			113	83	19	39	49	303
	5			28	56	20	41		145

Whilst Adele's favoured teacher move was to probe learner understanding in cycle 2, Kate's preferred teacher move was to evaluate a response, or she was concerned with procedural matters. Both teachers more than tripled the number of teachers' moves comparing cycle 2 with cycle 4. Probes and toss backs counted for almost two thirds of Adele's teacher moves as she provided opportunities for learners to explain their meaning, during cycle 4. A similar trend occurred in Kate's class where 56% of the teacher moves coded in cycle 4 were toss backs and probes. Whilst teachers continued to evaluate learner responses, the number of times this occurred was fewer than the toss back and probe moves.

Table 26 Kate: Teacher Moves

	Cycle	Ignore	Cut off	Toss Back	Probe	Elaborate	Evaluate	Procedural	Total
Year 1	1			13	4	3	12		32
	2			26	19	16	30	33	124
	3			8	8	9	21	1	47
Year 2	4		1	144	77	36	42	93	393
	5			18	33	20	31		102

A similar pattern was found when comparing the teacher moves across the two year for the light content, not only did the number of interactions increase in year 2 (cycle 5) so did the number of toss back and probe teacher moves.

5.5.2 Luke and Jenny: Teacher Moves

Most of Luke’s moves were coded ‘procedural’ during cycle 2 (64%) (see Table 27). Luke was concerned with moving the lesson forward as planned. To do so, Luke’s focus was twofold: first, ensuring learners followed activities as instructed, with little room to explore ideas further and second, dealing with poor behaviour.

Table 27 Luke: Teacher Moves

	Cycle	Ignore	Cut off	Toss Back	Probe	Elaborate	Evaluate	Procedural	Total
Year 1	**1**	2	10	21	5	14	30		82
	2	3	1	4	4	4	8	42	66
	3		1	2	10	4	7		24
Year 2	**4**	14	2	21	35	9	26	126	233
	5			6	29	9	21		64

Comparing how Luke responded to learners in cycle 4, there was an increase in all types of teacher moves. His preferred teacher move was still ‘procedural’, counting for 54% of the teacher moves (see Table 27). Once again Luke was frustrated by learners in his class who were disruptive, did not follow his instructions and were disinterested in the topic. It was in cycle 4 where fourteen of his moves were coded as ‘ignore’ as four girls struggled to stay on task. Luke explained in his final interview the reason why some learners did not participate in the activities was because learners sometimes claim that the activities were not novel to the them and they do not bring their books to school.

Luke *They were the ones that never got their stuff here. They haven't got their books there, that's waiting for other people to do it. And they'll never get to know it, it's because they have done this before. You know "I've done this before, I know this. "*

Jenny *You think that's the main reason they are disinterested?*

Luke *I think that's the main reason why they were disinterested.*

Luke Final Interview

Whilst the number of Luke’s teacher moves declined comparing cycle 2 with cycle 3, half the moves with the light content were probes and toss backs, following discussions from reflect 2 where time was spent considering the various communicative approaches. The teaching of the light happened during the last two weeks of term 3. By this time, all assessments for all subjects had been completed and those learners who tended to disrupt lessons did not attend school. These included absences by both participant and non-participant learners. As these learners were not in class, Luke was not focused on classroom management and keeping learners on task, rather he was able to explore learner meaning deeper using probes and toss backs. No 'ignore' moves were coded from cycle 3.

In year 2, the first week of cycle 5 took place in the final assessment week, with the second week of data collection taking place after the completion of the term's assessments. In the second week of data collection many learners did not attend school, particularly those that were easily distracted. Without disengaged learners in the class 54% of Luke's moves were coded as probes and toss backs and not a single 'ignore' teacher move occurred (see Table 27). I will discuss absenteeism in more detail later (see 5.6.2**).**

Results of the teacher moves I used for my lessons showed a similar trend to Luke for cycles 2,3 and 4. When comparing the teacher moves from cycle 2 to cycle 4, there was a four-fold increase in the number of teacher moves. Whilst some learner responses were evaluated, the preferred teacher move was toss back and probes, counting for 61% of the teacher moves (see Table 28).

Table 28 Jenny: Teacher Moves

	Cycle	**Ignore**	**Cut off**	**Toss Back**	**Probe**	**Elaborate**	**Evaluate**	**Procedural**	**Total**
Year 1	**1**			8	4	8	18		38
	2		1	26	24	8	17	7	83
	3	1	1	24	38	11	40		115
Year 2	**4**		3	110	134	42	54	54	397
	5			12	56	9	25		102

However, comparing teacher moves from cycle 3 to cycle 5, there was a slight decrease in the number of moves I made. In cycle 3, 54% of the teacher moves were toss back and probes, whereas in cycle 5 this had increased to 67%, evaluating learner contributions was not as common. I will explore teacher moves in my lessons, by unpacking the shadow activity in year 1 and year 2.

5.5.3 Teacher Moves: 'Shadow activity' – Jenny

On the day learners completed the shadow activity the weather was overcast, with the sun coming out from behind the clouds on and off. Once the sun was out learners were asked to move to the rugby field to complete the activity. However, by the time we reached the rugby field the sun had disappeared behind the clouds. The school's sports organizer was video recording my lesson and he suggested we go to the gymnasium and switch on the lights. Once the learners began the activity, I moved between the groups focusing learners' attention on the position of the light source and why shadows form. The following is an excerpt of such an exchange between a group of girls (Naledi and Candice) and myself:

			Teacher move
Turn 272	Jenny	*... So, tell me what's happening? Where's the light shining from?*	I
Turn 273	Naledi	*From here.*	R
Turn 274	Jenny	*So, what, what do we say that is?*	Toss back
Turn 275	Candice	*A light bulb.*	R
Turn 276	Jenny	*But the light is shining from it, so what is the fancy word we use?*	Toss back
Turn 277	Naledi	*Light source.*	R
Turn 278	Jenny	*It's luminous. yes. You were right.*	Evaluate
		So then what's happening Candice? The light is shining from there to where?	I
Turn 279	Candice	*As the object forms the shadow.*	R
Turn 280	Jenny	*Why does the shadow form?*	Toss back
Turn 281	Naledi	*Because there is a light going through, passing through.*	R
Turn 282	Jenny	*Exactly. So, that's why the shadows forming. If there's no light, it's dark.*	Evaluate

In this excerpt I ask learners a question and then use toss backs, giving each girl a chance to reply or add on to what a classmate had said. I start exploring what the girls know about how shadows form by having the girls explain where the light source is. In exchanges turn 272 to turn 278, I am wanting mention of the term 'luminous', as this was taught in a previous lesson. I use 'toss back' teacher moves between the girls, until Naledi replies; Light source' in turn

277. Here I hear what I am looking for and I evaluate the response. Before agreeing that Naledi is correct, I mention the word ‘luminous’ followed by a ‘You were right’ in turn 278.

In turn 280 I ask Naledi to explain ‘why does the shadow form?’ as a toss back to Candice’s incomplete answer. As I had rephrased the question to a ‘why’ question, Naledi responds with a reason. Once again hearing the response I am looking for I use an ‘evaluate’ teacher move to confirm Naledi’s reply: ‘Exactly’ (Turn 282).

In this excerpt I initially agree with Naledi’s alternative conception on why shadows form (Turn 282). However, I correct this alternative conception by stating the correct science concept that the reason why the shadow formed is because there is no light.

Only Adele and I allowed time for learners to report back on the activity once learners had returned to class. The purpose of the report back was to focus the learners’ attention on the position of the sun and the relative position of the shadow. Given below is part of the transcript from the report back, where I use prompts and toss backs to allow learners to explain their meaning. For example,1 in turn 358 Denzil replies with a single word: ‘luminous’, when asked about a shining light. I used a prompt to have him explain what the term means, by repeating the word luminous and continuing with ‘because it’s…’. Denzil completes my sentence in turn 360 ‘It’s giving off light’ Satisfied with Denzil’s response I repeat his reply ‘It’s giving off light’ as an affirmation of his response. This teacher move was coded as ‘evaluate’.

			Teacher move
Turn 357	Jenny	*All right, so you had the light shining and there was a person and a shadow. So, the light shining, we say the light is what?*	I
Turn 358	Denzil	*Luminous Ma'am.*	R
Turn 359	Jenny	*Luminous, because it's ...*	Prompt
Turn 360	Denzil	*It's giving off light.*	R
Turn 361	Jenny	*It's giving off light. Ok, so the light shines and it hits the person. So which way are your arrows going? From the light to the person, or the person to the light?*	Evaluate

In year 2, when giving learners instructions to complete the shadow activity, I ask learners to pay attention to the position of the sun, position, size and shape of their shadow, the position of the ‘feet’, ‘arms’ and ‘head’ of the shadow. Whilst learners were completing the activity, I walked amongst the groups asking questions. As learners had struggled to stay on task at the start of the lesson, I was frustrated by their poor observation skills.

			Teacher Move
Turn 125	Jenny	*Now here, here she is standing. How can you draw her shadow there? Where's her shadow?*	I
Turn 126	Siphu	*In front of her.*	R
Turn 127	Jenny	*In front of her. Look her feet are with her feet and her head's away. But now look you've drawn. There's the person, there's the shadow. The shadow should be there. You've drawn it over there.*	Elaborate
Turn 128	Kuhle	*Ma'am is this right?*	R
Turn 129	Jenny	*Yes. Ok, now look, look Siphu is standing there. There's the sun. Come, where's your picture? So, there's the sun, there's Siphu, where's your shadow? Go look on your diagram.*	Evaluate

Jenny Year 2 Shadow lesson

In the excerpt above I initiate an interaction with Siphu by asking him to observe where Kuhle’s shadow is cast. Although this question does not allow for single word responses Siphu’s response is a phrase ‘In front of her’ (turn 126). I respond to Siphu with an ‘elaborate’ teacher move as his response was incomplete and I wanted him to make better observations, paying attention to the position of the feet and head of the shadow relative to the person from which it was cast (turn 127). This then triggered Kuhle to ask if she had drawn her shadow correctly. A scan of Kuhle’s diagram is given in Figure 7 below.

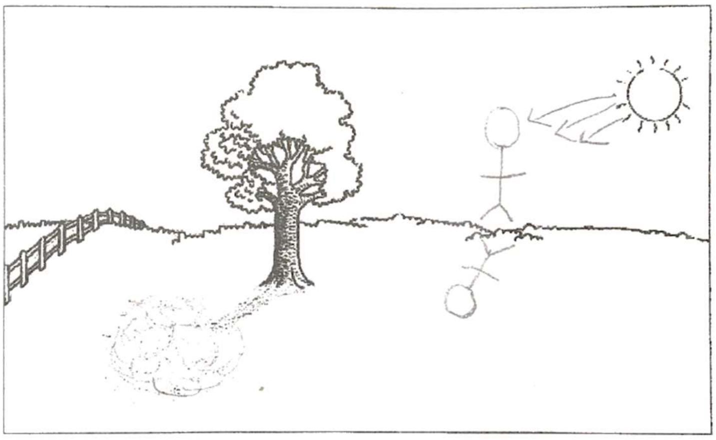

Figure 7 Kuhle's shadow diagram (year 2)

When interacting with learners I was mostly concerned with them observing their shadows correctly. Having completed the activity learners were asked to return to the classroom. Whilst most returned quickly, others chose to dawdle back to class, arriving some 5 minutes after their classmates. As I had struggled with off task learners at the start of the lesson, learners who were not observing carefully during completion of the task and now some took their time to get back to class, I made the choice to use a non-interactive authoritative communicative approach to go through the report back., see excerpt below.

Turn 137	Jenny	*I want to go through shadows with you so you can correct it. You are taking so long to get back. Five, four, three, two... Ok now. ... I'm so glad that I am recording these lessons. So, that when one of you records me flying off the handle, then I am going to play these lessons back to your parents and show them just what you do to drive the teachers to the state that some learners do. All right, now some of you took five minutes to get back here, it is unacceptable. We've got work to do. All right now what you need to do is to make sure that you, you understand how a shadow falls. So, you'll have er, something that's lumin, that's luminous, like the the sun, or over here there is a spot light. It will shine on an opaque object like a person. And because the light is being absorbed by that person. Behind that person a shadow will fall. All a shadow is is an area where there is no light. So, when you look, and this is something that you are not doing... you're not correcting your work, as I go through it. You should have lines coming from the sun. So, if I draw it on the board, and I know you have to go. Here's the sun over here.*

You should have an arrow showing the direction that the light is going. Then you should have the person that was standing there. Now the light is shining and hitting there. So, the shadow over here will fall and the feet should be with the feet. And in fact I am drawing it wrong. The shadow will fall like that with the person. Their shadow will fall. Where the light doesn't go through. Now, if you had to do the same with the tree. the tree was standing um, on this side. The light would hit the tree, so the shadow would fall here.

Jenny Year 2 Shadow lesson

My frustration was evident in the third and fourth sentences where I refer to myself 'flying off the handle' because of learners 'driving teachers to this state'. There was a decrease in the number of teacher moves comparing cycle 3 and cycle 5. Whilst probes and toss backs were used when discussing the shadow activity in year 1 (cycle 3), due to learners struggling to remain on task, in year 2 fewer of these teacher moves occurred. Learners going off task and or becoming disruptive resulted in shutting down interactions, and I reverted to non-interactive authoritative communicative approach, where I did not explore LPK at all.

5.5.4 Conclusion: Teacher Approaches and moves: "E" and "P" in IRE and IRPRE

Teacher moves coded in the baseline practices, cycle 1 were predominantly evaluation utterances. Having developed activities to work with various sources of LPK, the number of teacher moves increased in cycle 2, with teachers probing learner responses more. Less experienced teachers showed an increase in both these moves. Disruptive learners frustrated Luke and I, resulting in teachers opting for a non-interactive authoritative communicative approach, therefore learner understanding was not explored, and fewer teacher moves occurred. The highest number of teacher moves occurred during cycle 4. Teachers now used a combination of moves to explore LPK, probing, tossing back, evaluating, and elaborating on learner responses. 'Probe' and 'toss back' were the teacher moves three of the four teachers used most frequently.

There was a decline in the number of teacher moves when comparing lessons concerned with EoEC and light. As stated previously the light content allowed fewer opportunities to interact with LPK compared to the topic EoEC. However, when comparing the same topic that was taught in year 1 with year 2, it was found that the number of teacher moves coded increased. This is not surprising as not there was an increase in the number of interactions, particularly IRPRE interactions. There was an increase in the latter type of interaction as teachers used more ‘probes’ and ‘toss back’ moves in the second of the study. When learners went off task, teachers opted to shut down discussions and move to a non-interactive authoritative communicative approach to maintain order in the class.

Having discussed how the patterns of interaction, learner contributions and teacher moves changed from one cycle to the next as teachers explored what learners knew, I now consider some other factors that influenced why teachers worked with LPK the way they did.

5.6 What factors influenced how teachers interacted with LPK?

Various factors emerged that influenced the choices teachers made when deciding on how they interacted with LPK through the project. Some of these factors stifled interactions, sometimes shutting them down, for instance disruptive learners, whilst others encouraged learners to make what they know explicit. I will discuss the three factors that emerged as influencing the choices teachers made as to how they were going to interact with LPK: disruptive and disengaged learners, absenteeism and working within a PLC.

5.6.1 Disruptive and disengaged learners

One of the factors that played a noticeable role in teachers deciding how to interact with LPK was the behaviour of learners. Classes being made up of learners coming from diverse backgrounds meant that learners came to class with wide-ranging understandings, as well as mixed levels of interest in a topic. Where learners were disinterested, they would sometimes become disengaged and go off task, disrupting those around them. Behaviour of learners that frustrated teachers was usually linked to one of three reasons: first, disengaged learners either distracted or were distracted by their peers. Second, one or two learners tended to move to groups where their friends were once the teacher’s attention was focused on another group. Finally, learners would not bring their workbooks, textbooks, or stationery to school. Much time was then spent on class management taking away from teaching and learning.

Over the two years Kate, Luke and I expressed our annoyance at having to deal with these issues. In her Light reflection notes in year 2 Kate wrote the following:

I find in my other class, learners are more restless, and there are more distractions, making the learning process slower, and a bit frustrating for me.

Kate Reflection Notes Year 2

In his second interview Luke spoke at length about disruptive learners. In the extract below Luke explains how some learners are engaged and participating when he asks questions, whilst others lose interest, go off task and distract other learners.

Turn 178	Luke	*A lot of times, you'll find that the kids will come up with the answers that, this one will be prep, quite prepared to give them all the answers. But then the other class gets, the rest of the class goes mad. And then you have to spend 5 minutes disciplining them so that they can carry on. So, discipline is a big issue with these. They don't have any, any reigning on their...*
Turn 179	Jenny	*Like self-control.*
Turn 180	Luke	*Self-control, if they want to talk, they'll talk. There's no such thing as before where you had to wait. You wait your turn. There is no such thing as. It's instant gratification with these kids. 'Oh, I want to say something, I'm not going to wait till break. And I'm going to say it.' And it's just the way that they are.*

Luke Interview 2 Year 1

Luke attributed the disinterest of some learners not only to instant gratification but also to disinterest in the in the subject.

But I think it is also just lack of interest. I mean a lot of it is lack of interest. Not all the kids enjoy Science, Maths, History, Geography etc. And this is where the problem comes in. And it has to be done, no matter what, what they want. I mean it's just, just lack of interest, for some of them.

Luke Interview 2 Year 1

When teachers became frustrated with disruptive and disengaged learners this led to teachers moving their lesson to a non-interactive authoritative communicative approach as this was the easiest way to manage the class. In year 2, both Luke and I opted for this approach when teaching the topic Light. When Luke was annoyed, he decided to leave out group work activities preferring to teach from the front of the class. Luke decided not to do the shadow activity with his class in the second year. In his final interview he explained his preference for using a non-interactive authoritative communicative approach.

There were obviously one or two, that's in a group, where a, where there were two in a group that just didn't want to do anything. But the people that wanted to do, they did it. So, that's, it's a 50, 50 there. It's, but in most cases, it's better. I find it *better that I just stand there, and I just show them the stuff and I give them the notes and that's it.*

Luke Final Interview Year 2

What follows are excerpts from the first two light lessons in year 2, that shows how I changed my lessons from using an interactive dialogic communicative approach to non-interactive authoritative as learners became disruptive and I became annoyed and wanted to gain control. I started the first lesson (turn 1 of the excerpt below) making my expectations explicit: learners should stay in their groups.

Turn 1	Jenny	*Right, what we need to establish from the outset before you sit down, is that when you sit down you stay in your place. So, Lebogang, I want you to repeat what I just said.*
Turn 2	Lebogang	*Ma'am?*
Turn 3	Jenny	*No look at me.*
Turn 4	Lebogang	*When we sit down, um, we have established stay in your place.*
Turn 5	Jenny	*Ok, Lebogang you are going to tell me, where is your place? Sorry? Where's your place? And where are you going to stay for the next 20 minutes or so?*

Jenny Year 2 Light Lesson 1

This was followed by me giving instructions on what learners needed to do in their pairs, to complete the first activities. It was not too long before I needed to reprimand a learner for leaving their group (Turn 40)

Turn 40	Jenny	*... Kuhle, what did I say, where's your group?*

Jenny First Year 2 Light Lesson 1

Having completed the activities, I wanted to go through learner responses as a whole class discussion, where many learners were given an opportunity to explain their meaning. However, managing this was difficult as some learners went off task and distract their nearby classmates, usually by talking out of turn. The first instance occurs during Turn 173

Turn 173	Jenny	*... Er, no we have, we have respect issues here. Kopano is talking Mohammed you may sit down, thank you.*

Jenny First Light Lesson Year 2

By turn 324 my frustration was evident having reprimanded learners 8 times, for distracting classmates while their peers are responding.

Turn 324 Jenny *Sorry, I can't hear. You see, this is what annoys me. How many times do I have to tell you to listen to each other?*

Jenny First Light Lesson Year 2

A third cause of learner disruptions occurs when learners do not have the stationery and books at school. When these are needed in the lesson learners then scramble to borrow or take from a classmate. All learners were in possession of these at the start of the school year. Given below is an excerpt from Luke's second interview where he explains that it is the disruptive learners who do not bring what they need to class and then claim they are 'bored'.

Turn 28 Luke *They were the ones that never got their stuff here. They haven't got their books there, that's waiting for other people to do it. And they'll never get to know it, it's because they have done this before. You know "I've done this before, I know this. "*

Luke Final Interview Year 2

The excerpt below is from my the first light lesson in Year 1, and is an example of one such incident where Kumi and Denzil go off task as Kumi does not have his stationery at school and starts asking Denzil to use his, while I am trying to teach.

Turn 194 Jenny *... Denzil, face the front now please. Let's see if it will work. Ok I will just hold the match up. So, Kumi I am going to be sending you elsewhere. You want to sit and talk when I am talking that's fine. And of course, it's not you, it's Sam. Even though I see the words coming out your mouth. Ok, so we'll just blame him. Now we'll have a full-on argument because you know you don't bring your stationery, but it entitles you to disrupt this class the whole time.*

Jenny Year 1 Light Lesson

Disruptive learners not only lose out on completing activities themselves, but they also distract their peers causing them to go off task. To keep order in the class teachers, make an on-the-spot decision to stop any learner talk in the class and move to using a non-interactive authoritative communicative approach.

5.6.2 Absenteeism

The study was conducted towards the end of the third school term both years. When collecting data in Year 1, the topic EoEC coincided when learners wrote their control tests during 'test weeks'. The light content was taught in the last two weeks of the term, learners had completed all their assessments. Learner attendance was higher (96.4% and 99.6%) when comparing the last two weeks of the term when EoEC was taught to when Light was taught (83.3% and 82.4%) (see Table 29).

Table 29 Learner attendance Year 1

EoEC		Light	
Week 1	Week 2	Week 1	Week2
96.4 %	99.6 %	83.3 %	82.4 %

In year 2, week 1 of the light content coincided with the last week of the 'test week'. Most of the learners attended school, (98.4%). Learner attendance when the EoEC was taught was much the same. This decreased to 74.3% learner attendance in the last week of school once all assessments had been completed. (see Table 30).

Table 30 Learner attendance Year 2

EoEC			Light	
Week 1	Weeks 2	Week 3	Week 1	Week2
98.8%	98.8%	97.4%	98.4%	74.3%

The above tables are only considering the participant learners. In both years, most of the non-participant learners did not attend school, once the assessments had been completed. This meant that the actual absentee rate was a lot higher than what I am reporting on.

Whilst teachers continued with the teaching programme once the 'test weeks' had been completed; many learners did not come to school. This made teaching difficult as a learner would miss out on a lesson and the teacher would need to spend part of the beginning of the lesson when the absent learner returned sorting out housekeeping.

Often when learners missed activities, many of them did not catch these up and submitted work that was incomplete. However, the learners who were absent from school were usually the one's responsible for going off task and disrupting their peers, so while these learners were away from school less time was spent on classroom management issues and more time of teaching and learning,

Having unpacked how learner behaviour and absence from school affected how teachers interacted with LPK, I now consider the influence that working collaboratively in a PLC had on how teachers interacted with LPK.

5.6.3 Working within a PLC

Teachers attended several PLC meetings during the project, to reflect and plan how to explore LPK in their lessons. After lessons were taught for each cycle a reflect meeting took place. Before lessons in the next cycle were taught a meeting concerned with planning how to teach lessons in the next cycle considering challenges identified in the reflect meetings occurred. A total of 9 PLC meetings took place. There was 100% attendance by the teachers at every meeting. In their final interviews I asked each teacher why they did not drop out of the project that demanded so much of their time, these were their replies:

> Adele: *I found value in what we were doing.*
>
> Kate: *I gained a lot. I gained content knowledge.*
>
> Luke: *I found it worthwhile. I got to see how other people teach.*

Various aspects of working in a PLC surfaced as being reasons why our meetings were well attended and productive: the role of the leader, learning from peers and reflection. I continue presenting my results by discussing each of these aspects in more detail and link these to their influence on how teachers interacted with LPK.

5.6.3.1 The role of the leader

Whilst the project was mine and I was driving it in terms of setting up meetings and timeframes, when it came to taking the lead in PLC meetings, Luke stepped up to lead meetings concerned with the content EoEC. Not only did he suggest this small section be the focus for cycle 2 and consequently cycle 4, he designed the first worksheet and put together the resource packs that were required in the first year. If Luke had not designed the activities and made the teachers aware of common alternative conceptions, it is unlikely teachers would have interacted with LPK the way they did when they taught EoEC.

In her interview at the end of the first year Adele makes mention the Luke's sound content knowledge and his willingness to share what he knows.

> *... I've seen Luke in a whole new light. Cause, um, the amount of, or the wealth of knowledge he has, is, is quite amazing. Um, and he taught me quite a few things, I was, I was duly impressed. But it was also, ja, we need to tap into that man's brain at some point.*
>
> Adele Second Interview, Year 1

Whilst Luke took the lead in the topic where his content knowledge was sound, I was the teacher who took the lead with the light content, reading up on alternative conceptions and considering the knowledge learners may already have. None of the other teachers came prepared with possible activities for learners. Whilst interviewing Adele at the end of year 1, I acknowledged that this content was not my ‘expertise’.

> *I was frightened of the light section. I'll be honest with you I was. It's not my expertise and I think that's what was nice about this, was we we, were thrown into sections we weren't really comfortable with.*
>
> Jenny (Adele Second Interview, year 1)

The first planning meeting for each topic was dependent on the leader having developed activities for the lessons. It was from the draft worksheets that discussions and debates on how to improve the activities occurred. If it had not been for one of the teachers stepping up and planning something to discuss, particularly the first plan meeting for each content area (plan2 and plan 3) it is unlikely that meetings would have been as worthwhile as they were and that interactions in the classroom would have been the same.

In my reflection notes at the end of year 1 I wrote the following:

> *Teachers have been amazing in my project and shown enthusiasm for improving learning. However, this needs one teacher to drive the entire* project.

Having one of the teachers take the lead by preparing activities on what needed to be taught and completed during lessons, created opportunities for much discussion during meetings. It was during these discussions where all teachers attending the meetings gained knowledge: both content and pedagogic, that influenced the way they interacted with LPK.

5.6.3.2 Learning from peers

When asked to reflect on what they had gained by attending the PLC meetings in their interviews at the end of the first year and in their final interview at the end of year 2, Adele Kate and Luke all spoke of a gain in both content and pedagogic knowledge.

Adele acknowledged that both her content knowledge on electricity had improved as well as pedagogic knowledge, specifically that concerned with designing worksheets, due to her involvement in PLC meetings. Below is an excerpt from her interview at the end of year 1.

Luke knows a lot about electricity. And just listening to him explain stuff. Made me think, 'oh that's how that works.' Um, so before it was just the concept that you knew. And that, that you could explain. But after Luke said certain things, it just clicked. If that makes sense. And so, I understood it better.

Um, also when it comes to setting worksheets. Um, it's not something we do often. But, um, setting these worksheets it, it actually, it made you think more like a learner. Um, as well as a teacher. So, what do I ask to get an outcome? But then what if that outcome changes? Do I change the question? Or how does this work? Or how do I make this better? How do I? Is this worse, or? Do you know what I mean? Um, as a teacher that helps. It's knowing how to set questions and how to change questions. Knowing where to put certain things. Where certain things do belong in that place. Or if it will be better somewhere else? And thinking those things through. Um, because we basically set a lot of tests and exams we, me like, I'm kind of programmed on how to set a test or exam. But I've never thought how to set a, er, worksheet, since I done my PGCE. um and so that for me was a very good learning curve actually. Ja.

Adele Second Interview Year 1

In her final interview Adele once again spoke of gains in her pedagogic knowledge concerning planning worksheets, including a move away from developing worksheets that were merely focussed on covering the curriculum content, to ones that were well thought out and included questions involving higher order thinking. By working collaboratively within a PLC teachers were able to develop worksheets that were well thought out. Given below is an excerpt from Adele's final interview:

Um, and so I think those type of things was important. Um, being able to sit with each other and talk about these things. I think it, compared to when you know, when you're sitting by yourself and you're putting these notes together and you're trying to make its CAPS compliant with this and that. And has all the things to it. Um, you're not thinking about the learners. You're thinking about, ok, it must have this information, that information. I need to put in pictures, to make it a little bit more interesting. And I need to this and that.

Um, and the first thing you're thinking about, is, what is these kids going to see when they read these notes. Um and so I think we should probably take a look at all of our notes and think what are these kids going to see when they see these notes? And we might have to break it done a little bit more and make a, more learner friendly. Um, and I think if we can do that *we can, I don't know get them on a higher level and start asking them higher level questions. Instead of just the basics.*

Adele Interview 2 Year 1

Adele acknowledges that it was by discussions that took place in the PLC, that she became aware of considering how learners would interpret activities and the importance of asking higher order questions.

In her second interview Kate discussed the value in hearing how other teachers teach a topic. When teaching the light content in the year before the study, Kate had sought advice from one of the senior Physical Sciences teachers, Magda, as Kate was aware her of her inexperience in teaching this content. When asked about her professional learning by attending PLC meetings Kate spoke of the value in hearing how different teachers explain concepts, as this added to her pedagogic knowledge, allowing her more options to draw on when explaining concepts.

Listening to how other people teach, is a very important thing, because I might be teaching one thing in a certain way. I mean when I started teaching light last year, I had no idea what I was doing, so I went to Magda and I asked her: 'how would you teach it?'. And she explained to me how she taught it. It made complete sense to me. But I might, I might explain it to the kids the way she explained it and they might not understand it. But maybe Adele teaches it a different way and I explain it like she understands and we you know, combine those two ways and they understand it. So, I think listening to what other, how other teachers teach is very important.

Kate second Interview Year 1

When asked the same question at the end of the project, Kate once again speaks of the value in hearing how others explain concepts that she was less confident with. Below is a short excerpt from Kate's final interview.

I think often times, where if you have the content, you need the confidence to teach it and I think with this, you go over it and over it again. And you hear how other, other people explain it. And then you realize, 'Ok, I can do this now.'

Kate Final Interview Year 2

Luke explained in his final interview that both his content knowledge and pedagogic knowledge had improved by attending PLC meetings. In turn 215, I agree with Luke that my content knowledge has improved.

Turn 210	Luke	*But I gained a lot. I mean my chemical stuff has improved by leaps and bounds since we've actually got into this stuff.*
Turn 211	Jenny	*Ok.*
Turn 212	Luke	*So, I know more what I'm talking about than what I did two years ago.*
Turn 213	Jenny	*So, your content as a teacher has improved a lot?*
Turn 214	Luke	*My content knowledge has improved phenomenally.*
Turn 215	Jenny	*And I would agree with that. Ok.*

In their interviews both Kate and Luke had gained so much from working collaboratively within the PLC, they hoped that these meetings would continue once the data had been collected. Kate specifically made mention of developing worksheets (notes) for other topics forming part of the curriculum, like those that were developed during the project.

> *I think we should actually be doing this. We have said it over and over again and I think we need to stick to our thing. Where we need to do this with all of the notes. Er, because it works, it really does work…. And I think if we did them all like this it would work a lot better.*
>
> Kate Final Interview Year 2

During Luke's second interview at the end of year 1, he states his hope that teachers continue to meet, to discuss restructuring worksheets in other topics in a similar way to the way they were done in the two topics forming part of the research.

> *I found it extremely useful. We could come out here, there's, three or four people with their own ideas. We went with their own ideas, we discussed different ways of doing things. And you took the best one out of that. I enjoyed it. I really and truly did, and I think we should have more of those things. Especially with the beginning of, of the section.*
>
> *I could do that with the electrical. We can show them exactly what we, what we need to have. And it does work, I mean Ecology. Ecology is quite strange to me. But there are different ways of doing it, I am sure much better ways than what I am doing it. And each person can put*

their input. It does take up a bit of time. But it's well worth it in the long run…. I think it is extremely useful, I enjoyed it.

Luke Second Interview Year 1

The above excerpt highlights the factors related to working in a PLC that influenced the way teachers interacted with LPK, first the functioning of the PLC was dependent on a motivated leader who not only came prepared with ideas that would stimulate discussion but was able to create a safe space for teachers to speak. Teachers were given opportunities to discuss both the content that needed to be taught and how to teach it. Through discussion lessons were prepared, in the process both teachers' content and pedagogic knowledge improved, and this influenced the choices teachers made in their classroom on how they interacted LPK.

5.7 Discussion

Creating opportunities for teachers to explore what learners already know is both complex and could place the teacher in a position where they have not planned for learner responses (Ball & Bass, 2000). From a constructivist approach to learning, it is when opportunities are created for learners to link what they already know to what needs to be learnt, that meaningful or deep learning occurs (Scott et al., 2011). In this chapter I have considered some of the factors that influenced why teachers interact with LPK the way they do. To answer this second research sub-question first looked at the patterns of interaction teachers opted to use when unpacking LPK, as well as considered how teacher questions influenced learner responses and explored what moves teachers favoured when responding to learner utterances that were associated with revealing LPK. The two factors that negatively affected the way teachers explore LPK, were disruptive learners and learner absenteeism. It was participation in PLC meetings that teachers identified as playing a role in changing how they interacted with LPK by improving both their content and pedagogic knowledge. I will now discuss how each of these aspects played a role in the way teachers interacted with LPK during their lessons.

5.7.1 Patterns of Interaction

At the start of the project the preferred pattern of interaction by all teachers was the triadic IRE. The IRE pattern of interaction has been prevalent in many classrooms since the 1990s (Lemke, 1990) and still occurs (Smart & Marshall, 2013). This pattern of interaction does not allow for teachers to deeply explore what learners already know. As Chiou and Anderson (2010) reported teachers tend to 'scratch the surface' when working with LPK, providing few opportunities to challenge alternative conceptions or to uncover 'gaps' in what learners should already know. With the focus of the project on working with LPK, teachers reflected and planned lessons that were concerned with working with LPK on a deeper level. Activities were reworked to consider various sources of LPK, possible alternative conceptions, as well as the types of questions teachers may ask and how they could respond to learner responses.

This resulted in an increase both the number of teacher-learner interactions that occurred as well as an increase in the IRPRE pattern of interaction. The number of interactions that occurred was dependent on the content taught. Learners come to class with more knowledge in some topics than others. It was through reflecting on previous lessons and considering what interactions were occurring that allowed teachers to plan and teach lessons, with the purpose of increasing the number of IRPRE interactions. This resulted in teachers using both IRE and IRPRE interactions to discover what learners know. There was a shift in focus moving away from wanting a correct reply from a learner to exploring learner understanding more deeply (Chin, 2007).

Learner behaviour played a role in the decision teachers made as to how to interact with them. When some learners in the class went off task and became disruptive, teachers either shut down any form of interaction, switching to a non-interactive authoritative communicative approach or interacted with learners using the triadic IRE approach. Juta and Van Wyk (2020) reported that in Mathematics classes in South Africa, teachers spoke of classroom management problems surfacing when learners are required to do activities in groups. However, their study asked teachers using interview questions related to classroom management and the authors did not experience these issues firsthand in classrooms. In my study, when learner behaviour deteriorated Luke either did not allow learners to complete the activity, particularly those activities that involved working in groups outside or he shutdown interactions with learners, preferring a non-interactive authoritative communicative approach. When I became frustrated by learners going off task and becoming disruptive, I too switched from using an interactive dialogic approach to a non-interactive authoritative communicative approach, shutting down any contributions from learners. As Mortimer and Scott (2003) state it is the teacher who decides on the type of interaction that takes place.

When teachers wanted to explore what learners already know on a topic, this was done using questions. I turn my discussion to consider the questions teachers asked and how this influenced the response of the learner.

5.7.2 Teacher Questions and Learner Contributions

If teachers wish to discover what learners know, the questions they asked should require learners to explain their meaning (Chin, 2006). Yet teachers tend to ask learners questions that are of a low order (Smart & Marshall, 2013) and are focused on learners providing an answer they seek to hear (Pimentel & Mc Neill, 2013). I was interested to find out: How are learner contributions influenced by the 'I' in the IRE or IRPRE patterns of interaction? By considering the type of questions teachers ask I was able to unpack learner responses. Low order questions tend to result in learners not needing to explain their understandings as their answers are usually phrases or single words (Smart & Marshall, 2013). It is when teachers ask questions that are open-ended that learners are given the opportunity to explain their meaning (Chin, 2007).

Learner responses from the first two cycles were characterized as being predominantly single words or phrases, as teachers asked low order questions. My findings were consistent with the findings from Nykiel-Herbert (2004) who reported that South African teachers in their research preferred to ask learners questions that were focused on basic recall, or were used to check if learners were paying attention. In some instances, teachers in my study asked learners questions of such a low order that learners responded in a chorus. Asking learners questions of a low order is not only a South African teacher phenomenon. In their study of 10 middle schools in the United States of America, Smart and Marshall (2013) reported that teachers relied heavily on lower order questioning. They found that lower order questioning correlated with lower cognitive levels for learners, learners were unable to explain concepts, and their understanding remained at basic recall. When teachers ask low order questions, where a single answer is deemed correct and all others incorrect, the teacher is placing themselves as the authority.

As teachers in my study moved to explore learner understanding more by using the 'probe' and 'toss back' moves, , so the number of learner responses increased, as learners were provided with more opportunities to respond. Making use of 'probes' and 'toss back' teacher moves encouraged learners to explain their meaning deeply, and this resulted in learners beginning to respond in full sentences, sometimes including reasons for their statements. Prompts and toss backs were usually a reply to higher order questions where the teacher would ask 'why' or 'how' or 'what do you mean' type questions.

This supports the findings reported by Chin (2006) where grade 7 learners from Singapore were able to make predictions, interpret and explain their meaning in response to teachers well thought out higher order questions. Although teachers in my study spent some time during plan 4 considering activities that would challenge common alternative conceptions held by learners, it was only in plan 5 where teachers planned higher order questions they could ask, with the hope of learners' responses providing insights into their understandings. At the end of the study learners were only starting to explain and interpret concepts. I will now consider how teachers reacted to learner responses.

5.7.3 Teacher moves

The third question I asked in this chapter was: What 'moves' do teachers prefer when working with LPK? As discussed in Chapter 4, the preferred teacher move by all teachers in their baseline lessons was to 'evaluate' learner responses. Evaluating learner responses is a common move many teachers use, either affirming the correct response or rejecting responses that were not planned for (Pimentel & Mc Neill, 2013). Once a learner response has been deemed acceptable or not, little room is given to explore learner understanding further.

During plan 4, teachers not only reworked activities focused on challenging alternative conceptions learners may have, teachers were also made aware of the probe and toss back move. Teachers planned how they could explore learner meaning deeper by using these two moves. As when teachers use probes and toss back moves learners are required to explain what they mean more fully and moves beyond the basic recall of knowledge (Chin, 2007).

The preferred teacher moves during cycle 4 for all but one teacher was 'probe' and 'toss back'. Teachers were now asking learners to explain their meaning more fully. However, when asking learners to explain what they are thinking more deeply, may result in the lesson moving off its predetermined path (Chin, 2006), something some teachers want to avoid. Instances occurred where some learners became disengaged and started to go off task, when the teacher was asking their peers to explain their meaning more fully. In these instances, the teacher decided to shut down the discussion using a 'cut off' or 'ignore' move to reduce the time spent having learners explain their meaning.

Working collaboratively reflecting and planning lessons resulted in teachers interacting with learners using both an IRE and IRPRE patterns of interaction. This was achieved as all teachers were committed to the project attending meetings to reflect and plan lessons. Teachers repeatedly planned, taught their lessons, and reflected on what happened in the classroom, during PLC meetings. Activities were revised, a repertoire of questions that encouraged learners to make what they know explicit as well as prompts and toss back moves were developed, as these influenced how teachers interacted with LPK. In answering the last question, what are the factors that influence how teachers how interact with LPK, I turn my discussion to consider how working within a PLC influenced the way teachers interacted with LPK, as it was here that discussions took place on how to do this better.

5.7.4 Working within a PLC

Working within a PLC planning and reflecting on activities, teachers were initially focused on what needed to be done by learners to complete the activity. Teachers were unaware of possible alternative conceptions learners may have that have been reported in academic literature. This confirms the findings of Duit and Treagust (2012) who state that many teachers are more concerned with the transmission of knowledge than staying abreast of developments in education research. Whilst much research has uncovered alternative conceptions learners may have in various topics, teachers in my study did not refer to this research when planning lessons. As this was my project and I had access educational research journals through the University's library electronic data basis, I was the only teacher who read up on these alternative conceptions. Even if teachers had access to these papers, searching and reading what education researchers have reported on is time consuming, I question how many teachers would spend time exploring current educational issues. The alternative conceptions teachers were aware of were those which had surfaced during lessons or those they had come to know about through experience.

Teachers were dependent on one of the experienced teachers highlighting alternative conceptions learners have. Luke was able to draw on his experience to state common alternative conceptions. I drew on what I had read in education journals having accessed the electronic data bases. For instance, Hardman and Riordan (2014) paper review of research concerned with the difficulties on teaching light and an earlier review by Osborne et al. (1993) on young children's perceptions on light.

Being made aware of the common alternative conceptions learners have concerning 'shadows' when teachers reflected on how learners had completed activities from the year before, teachers planned for these alternative conceptions in lessons that were to be taught. When these alternative conceptions surfaced in lessons in the second year, teachers were able to challenge these, by asking higher order questions and using teacher moves that included probes and toss backs. This required learners to respond in full sentences and to give reasons for their thinking. As a result, the patterns of interaction that occurred included more IRPRE exchanges and not only IREs.

Although the leader changed with change of topic in my project, the role of the leader is crucial in ensuring the PLC meetings are successful. In my project not only was the leader motivated, prepared and came with some expertise on the content to be taught, the leader ensured that a safe space was created, where teachers felt respected. Durksen et al. (2017) have stressed the importance of PLCs providing a trusted environment. Brodie (2013) goes so far as to state that the success of a PLC is dependent on the leader ensuring that teachers feel free to participate in discussions without fear of being ridiculed.

It was by working collaboratively developing activities and reflecting on lessons where teachers acknowledged that both their content and pedagogic knowledge increased. Successful PLCs are dependent on teachers from the same context reflecting on shared experiences (Brodie, 2013). It was through reflection and planning that teachers changed the way they worked with LPK, moving from using a predominantly interactive authoritative communicative approach to including an interactive dialogic communicative approach in their lessons. By working in a PLC teachers were given an opportunity to move from what they could do on their own to that which they could do given a little assistance, teachers had moved through their ZPD.

5.8 Conclusion

Integrating LPK into science lessons is complex, requiring considerable planning before lessons are taught. Not only do teachers need sound content knowledge, they need to consider various sources of learners may have acquired their prior knowledge from, as well as planning for possible alternative conceptions.

The results from this study showed teachers moved their practices from including predominantly IRE class patterns of interactions to ones which include episodes of both IRE and IRPRE, when exploring LPK, by making use of probes and toss back moves.

When teachers considered the types of questions (I) they were asking, and changed these to include higher order questions, learner responses became complete thoughts often including a reason for the thought. Where learner responses were single words or phrases teachers probed the learner to explain their meaning more fully. Sometimes a teacher would ask a classmate to explain further, using a toss back move. Thus, lessons moved from using predominantly an interactive authoritative communicative approach to ones including an interactive dialogic communicative approach.

When learners became disruptive teachers' interactions with learners reverted to either IRE interactions, where learner responses were evaluated as being correct or incorrect or the teacher shut down interactions, opting for a non-interactive authoritative communicative approach In this way the teacher was able to restore order to the class and at the same time move through content.

When teachers are committed to working collaboratively in a PLC reflecting on their practices and planning new lessons, it is possible to develop activities and strategies that allow teachers to work in a meaningful way with LPK, moving learners through their ZPD.

Successful PLC meetings were dependent on a motivated leader who created a safe space for teachers to speak freely. The leader was the person who came prepared with activities, considering possible alternative conceptions learners may have. Teachers were aware of learner alternative conceptions from their own experiences. Even though there is much research on alternative conceptions learners may have, this is not accessed by teachers, and the gap between research and teaching is evident.

The leader required sound content and pedagogic knowledge to start conversations guiding teachers as they move through their zones of proximal development. Being aware of the types of questions teachers could ask learners, listening to learner responses and exploring these responses further are important in gaining a deeper understanding into the knowledge learners bring with them to class.

Teacher reflections were crucial in changing the way teachers interacted with LPK, from one cycle to the next. In the next chapter, I discuss how teachers' participation and level of reflection changed from one PLC meeting to the next.

Chapter 6

Working within a PLC: Exploring teachers' participation and reflective practices

6.1 Introduction

Practical action research is concerned with teachers seeking ways to improve their practices by reflecting on what happened having taught a lesson. Based on these reflections, revisions are made when planning the following lesson. Teachers are guided what to do by following the revised lesson plans when teaching the following lesson (Mc Millan & Schumacher, 2010). It is through continuous reflection and planning, where teachers find solutions to a problem they have identified. In Chapter 4, I described how teachers interacted with LPK in their baseline practices. In Chapter 5, I unpacked how and why these interactions changed as teachers reflected on how they interacted with LPK over two years when teaching the content EoEC and Light. Chapters 4 and 5 have examined the 'Act' and 'Observe' phases of the cycles of the Practical Action Research.

In this chapter, I consider teachers' reflective practice by analyzing the 'Reflect' and 'Plan' phases. Having taught the same lessons teachers met as a PLC to reflect on what had happened and why it happened, in a 'reflect' meeting. Following the 'reflect' meeting, teachers attended a 'plan' meeting where what had been discussed in the 'reflect' meeting was used to make changes adjust activities and make changes to the lesson plan. I have labelled the various meetings as being either 'reflect' or 'plan' followed by the cycle number in which they occurred, for instance reflect 1, refers to the reflect meeting that took place in cycle 1, this meeting was concerned with reflecting on baseline practices (see Table 31).

I have included plan meetings in the data analysis on reflective practices, as plan meetings included episodes where teachers would reflect on what had happened and suggest solutions to difficulties encountered.

Table 31 Plan and reflect meetings over the two years of study

Year	Cycle	Topic of Lesson	Description of meeting
Year 1	Cycle 1	Baseline Lessons	Reflect 1
	Cycle 2	Effects of Electric Current (EoEC)	Plan 2
			Reflect 2
	Cycle 3	Light	Plan 3
			Reflect 3
Year 2	Cycle 4	Effects of Electric Current (EoEC)	Plan 4
			Reflect 4
	Cycle 5	Light	Plan 5
			Reflect 5

The focus of the data analysis was to explore how teacher participation and the level at which teachers reflected changed (or didn't) through the cycles. With this focus I was able to answer my third research sub-question: What influence does attendance at successive PLC meetings focused on reflecting how teachers engage with LPK, have on teacher participation within the PLC and the level of at which teachers reflect?

From transcripts of reflect and plan meetings 'reflective episodes' were identified. A reflective episode occurred when a teacher suggested exploring an aspect of the lesson requiring improvement in the way teachers engage with LPK. I start the chapter by broadly considering the number of reflective episodes coded for each meeting. I go on to consider how teacher participation in the PLC changed with continued attendance at reflect and plan meetings. This is followed by an analysis, tracking the level at which teachers reflected through the cycles. I explore how each teacher's participation and level at which they were reflecting changed over the two years.

Data have been coded to identify which teacher initiated a reflective episode (initiated reflection) and those that contributed to discussions (discussed reflection). Teachers were only coded once in a reflective episode, even though there may have been much back and forth discussion within the same reflective episode. Teachers were coded at the highest level of reflection for each reflective episode. I start my analysis of teachers' reflective practice by discussing the number of reflective episodes coded for each meeting over the two years.

6.2 Number of Reflective Episodes: Reflect and Plan Meetings

To answer the first part of the third research sub-question: What influence does attendance at successive PLC meetings focused on reflecting how teachers engage with LPK, have on teacher participation within the PLC, reflective episodes were identified for each of the reflect and plan meetings. The number of reflective episodes per meeting has been tallied (see Table 32), to get a sense of the number of issues and concerns teachers raised when reflecting on lessons. The total number of reflective episodes coded during reflect meetings focused on EoEC (reflect 2 and reflect 4) was much the same for both years, ranging between 14 and 18 episodes. However, the number of reflective episodes for the same content in the 'plan' meetings, (plan 2 and plan 4) was more (25 and 35 respectively), compared to the reflect meetings, (see Table 32). The highest number of reflective episodes occurred in plan 4, (35), this being more than double the number of reflective episodes that occurred in reflect 1 (see Table 32).

Table 32 Number of Reflective Episodes

	Reflect Meetings	Topic	Reflective Episodes
Year 1	Reflect 1	Baseline Lesson	16
	Reflect 2	EoEC	18
	Reflect 3	Light	6
Year 2	Reflect 4	EoEC	14
	Reflect 5	Light	6
	Plan Meetings	**Topic**	**Reflective Episodes**
Year 1	Plan 2	EoEC	25
	Plan 3	Light	5
Year 2	Plan 4	EoEC	35
	Plan 5	Light	12

Before discussing the number of reflective episodes occurring in the 'light' reflect and plan meetings, it needs to be noted that the content EoEC provided more opportunities for teachers to interact with LPK than what the light content allowed for. This was because learners were familiar with various appliances that use electricity as well as some of the content had been taught in previous grades and subjects, as discussed in Chapter 3. The same cannot be said for the light content of work, where LPK was only explored in the introductory 'light' lessons, consequently fewer reflective episodes were coded. The number of reflective episodes occurring in reflect meetings when comparing the two years for each topic (EoEC and light) remained much the same (see Table 32): 18 reflective episodes (reflect 2, EoEC year 1) vs 14 reflective episodes (reflect 4, EoEC year 2) and 6 reflective episodes (reflect 3, light year 1) vs 6 reflective episodes (reflect 5, light year 2).

When comparing the plan meetings focused on the same content year on year, many more reflective episodes occurred in the second year of the project. For the topic EoEC, 35 reflective episodes were coded during plan 4 in year 2, compared to 25 reflective episodes in plan 2 (year 1). For plan meetings focused on the topic ‘light’, 12 reflective episodes (plan 5) were coded in year 2, compared to 5 reflective episodes (plan 3) in year 1, see Table 32.

More reflective episodes were coded in meetings concerned with the topic EoEC compared to those where teachers were reflecting on what happened during their ‘light’ lessons. Except for plan 3, more reflective episodes occurred in the ‘plan’ meetings compared to the ‘reflect’ meetings when comparing meetings in the same cycle, for instance during plan 2, 25 reflective episodes were coded compare to 18 reflective episodes in reflect 2. This may be because teachers were aware that following the plan meeting, they were required to teach what had been discussed. When comparing the same type of meeting year on year, it was only in the ‘plan’ meetings that an increase in the number of reflective episodes occurred. An indication of participation of individual teachers is given in the next section when considering the level at which teachers reflected.

6.3 Levels of Teacher Reflection

Each reflective episode was initiated by a teacher making a statement or asking a question. In most instances, this resulted in a discussion amongst the teachers. Some discussions were concerned with teachers confirming each other’s findings, whereas others were more robust, where differences between learners or classes were discussed, as well as possible solutions to areas of concern. A distinction has been made as to whether a teacher initiated a reflective episode or whether the teacher was merely part of the discussion. The excerpt below (see Table 33) taken from the reflect 2, illustrates how I coded reflective episodes.

Table 33 Coding of Data: Levels of Reflection

Teacher	Transcript	Level of Reflection		Explanation of coding
Adele	*I found that even though they are a really nice class, some of them weren't following instructions*	Initiated	Basic technician teacher	Not following instructions: problem stated, no solution.
Jenny	*... I also thought mine didn't follow instructions, but they follow instructions in some places and not in others.*	Discussed	Basic technician teacher	Acknowledges that sometimes learners don't follow instructions.
Luke	*They sort of jump the gun. That's what I have sort of written over there. That they actually jumped to the more interesting parts, so we will quickly scan through this to say, 'I have' and 'here's' an experiment.*	Discussed	Craftsperson	Provides a reason to learners not following instructions.

In this extract Adele initiated the reflective episode raising a concern regarding learners' inability to follow instructions. Adele was coded 'initiated' as she began the reflective episode. Luke and I joined in the discussion of the reflective episode and were coded 'discussed'.

Individual teacher reflections within each episode were coded using Zeichner and Liston's (1987) levels of reflection: Technician teacher; craftsperson, moral craftsperson as well as O'Sullivan's (2002) 'basic technician teacher'. Where teachers could identify problems or raise issues, without giving possible solutions, the level of reflection was coded as 'basic technician'. In the above excerpt (Table 33), Adele and I can state the problem: learners do not follow instructions. However, neither gave a reason why they thought this was so. Therefore, their reflections are both coded as 'basic technician'. Reflections that were concerned with completing that which was decided by someone else (e.g. the curriculum) were coded at the level 'technician.' A teachers' level of reflection was coded 'craftsperson', when their reflection was concerned with why certain actions had occurred. In the above excerpt it was Luke who gave a possible reason why learners did not follow instructions: they were scanning the worksheet to find more interesting activities (see Table 33). The highest level of reflection Zeichner and Liston (1987) classify is one where moral and ethical considerations are given to explaining an event: moral craftsperson. No teacher reflection in my study was coded at this level. I coded a teacher once for each reflective episode they participated in, regardless of the number of contributions they made in the reflective episode. The highest level of reflection at which a teacher was coded at for each reflective episode recorded.

I addressed the issue of internal reliability by making use of interrater reliability. Inter reliability requires that two or more individuals make observations or code data to see how well their scoring coincides (Creswell, 2012). As coding is done by at least two individuals it has the advantage of negating possible bias a single researcher may have. I asked a critical friend to independently code one meeting (reflect 4). Having explained the various levels at which teachers reflect and providing him with the transcript of reflect 4, we found that 91% of our codings for the levels at which teachers reflected were the same. Where there was a discrepancy in our coding much discussion and negotiation resulted. Most of these instances resulted from my critical friend being unfamiliar with the context of the reflective episode. Once the context of the reflective episode was explained, 4% of his codings changed to matched mine. I did all final coding.

Before separating teacher reflections into 'initiated' reflective episodes and 'discussed' reflections, I have tallied the various levels at which teachers reflected, for each meeting (see Table 34). I have also provided a sum of the various levels of reflection for each meeting. Combining the data provides an overview as to how teacher participation changed during the two years.

Table 34 Levels of Teacher reflections for Reflect and Plan Meetings

	Year 1					**Year 2**			
	Reflect 1	**Plan 2**	**Reflect 2**	**Plan 3**	**Reflect 3**	**Plan 4**	**Reflect 4**	**Plan 5**	**Reflect 5**
Craftsperson	18	15	20	4	3	47	15	11	2
Technician	6	20	6	6	7	23	6	11	8
Basic Technician	0	6	10	6	6	17	24	8	7
TOTAL	24	41	36	16	16	87	45	30	17

The number of instances teachers participated in reflective episodes tallied more for the content EoEC (cycles 2 and 4) compared to the 'light' content (cycles 3 and 5). Comparing plan 2, teacher participation was counted 41 times, compared to 16 instances in plan 3. Similarly, for year 2, comparing plan 4 (EoEC) with plan 5 (light), teacher participation in reflective episodes totaled 87 times (plan 4) compared to 30 (plan 5). Not only were teachers more active in meetings focused on the content EoEC (cycles 2 and 4), but more instances of teachers also reflecting at the craftsperson level were coded in these meetings, compared to the light content (cycles 3 and 5).

When comparing plan and reflect meetings for a cycle, for example plan 2 with reflect 2, teacher participation in reflective episodes was higher for the plan meeting when compared to the reflect meeting. For instance, in cycle 2 teacher participation in reflective episodes in reflect 2 was tallied to 36, compared to 41 instances for plan 2. This was true for all cycles, except cycle 3, where teachers participation in reflective episodes for both plan and reflect meeting was the same: 16. When considering the level at which teachers were reflecting comparing plan and reflect meetings for the same cycle: in all but one cycle (cycle 2) more instances of teachers reflecting at the craftsperson level occurred during plan meetings.

When comparing the corresponding meeting, (plan and plan; reflect and reflect), for the same content area year on year (e.g. plan 2 and plan 4; reflect 2 and reflect 4; plan 3 and plan 5; reflect 3 and reflect 5) in all instances the participation by teachers in reflective episodes increased. However, it needs to be noted that the increase, year on year was more in the plan meetings: an increase of 46 contributions (EoEC) and 14 contributions (Light). This compares with an increase of 9 contributions for the EoEC (reflect 2 vs reflect 4) and an increase of only 1 contribution for light (reflect 3 vs reflect 5), for the reflect meetings year on year. Further, when examining the level at which teachers reflected, year on year, for the same content area (EoEC vs Light), and the same type of meeting (plan vs reflect) an increase the reflective levels: basic technician, and technician, occurred (see Table 34). When exploring what happened at the craftsperson level of reflection, the results for the plan and reflect meetings are different. For the plan meetings the number of craftsperson level of reflections for both EoEC and Light plan meetings increased, year on year, 27 more for EoEC and 7 more for light. However, this was not the case for the reflect meetings, as for both content areas there was a decrease in year 2 for contributions coded at this level: a decline of 5 (EoEC) and 1 (light, see Table 34).

I continue the analysis of my data by teasing out the data in more detail. First, I will separate out reflections within reflective episodes that were initiated, and compare this to those were teachers participated in a reflective episode (discussed reflections) and then I will look at data for each of the participant teachers: Luke, Adele, Kate and myself as this gives insight into individual teacher's reflective practice. Data from the same type of meeting (reflect or plan) has been grouped together.

6.3.1 Reflect Meetings:

As discussed in Section 6.2, the total number of reflective episodes remained much the same for each content area, year on year for the reflect meetings. To unpack the meetings, I have separated the data on reflective episodes into two groups: first reflections that teachers initiated, and then grouped reflections where teachers participated in discussions together. The former group was categorized as 'initiated reflective episode' and the latter 'discussed reflections'.

When comparing the level of reflection for the different content areas, i.e., comparing the level of reflection for reflect 2 and reflect 4 (EoEC), compared to reflect 3 and reflect 5 (light), more initiated reflections were coded at the craftsperson reflection level, for the EoEC content. The level of initiated reflections by teachers for the light section of work (reflect 3 and reflect 5) showed an even spread of the various levels of reflection. For instance, in reflect 3, 6 reflections were coded, 2 at the craftsperson level, 2 at the technician level and 2 at the basic technician level (see Table 35). When comparing how the level of initiated reflective episodes changed (or didn't) year on year, there was a decline in the number of reflections at the craftsperson level from year 1 to year 2, for the EoEC (reflect 2 and reflect 4). In year ,1 66% of the initiated reflective episodes were coded as craftsperson, whereas in year two this had dropped to 57%. For the light content, the number of initiated reflective episodes coded at the craftsperson level remained at 33% for each year.

Whilst the level of reflection dropped in one topic and stayed much the same in another topic when comparing year 1 and year 2, initiated reflection, it is important to remember initiating a reflective episode provides an opportunity for teachers to reflect on what had transpired in their classrooms and is the springboard for further reflection.

Table 35 Levels of Initiated Reflective Episodes in Reflect Meetings

	Year 1			Year 2	
	Reflect 1	**Reflect 2**	**Reflect 3**	**Reflect 4**	**Reflect 5**
Craftsperson	13	12	2	8	2
Technician	3	2	2	2	1
Basic Technician	0	4	2	4	3
TOTAL	16	18	6	14	6

Discussed reflections provide insights into how many teachers participated in reflective episodes in a meeting. By comparing the number of discussed reflections to the number of initiated reflective episodes for the same reflect meeting it is possible to work out how many teachers participated in a discussion. For instance during reflect 1, 16 reflective episodes were initiated, (see Table 35) and 8 discussed reflections occurred (see Table 36). This would mean that at least 8 reflective episodes did not have any back-and-forth discussion. The teacher who initiated the reflective episode raised a concern which none of the other teachers commented on. Yet, looking at reflect 4, a total of 14 reflective episodes were coded (see Table 35), with a total of 31 discussed reflections occurring (see Table 36). If all teachers had participated in all the reflective episodes during reflect 4, then three times the number of discussed reflections would have occurred. In other words, if all four teachers participated in a reflective episode, this would mean the number of discussed reflections should have been 300% of the total of the initiated reflective episodes. Thus, when comparing the change in percentage in number of discussed reflections compared to initiated reflective episodes, across the meetings the following occurred: reflect 1, 50%; reflect 2, 100%; reflect 3, 167%; reflect 4, 221%; reflect 5, 183%. There is a steady increase in participation, from reflect 1 to reflect 4. Whilst reflect 5 saw a slight decline in participation dropping from 221% in reflect 4 to 183% in reflect 5, it needs to be remembered that teachers were aware that reflect 5, was the last of the data collection for the entire project. This may have affected teachers' participation in the meeting as they were aware the following year their classes would not be recorded.

When comparing the level of discussed reflections in the reflect meetings, the number of reflections coded at craftsperson for each content area was much the same comparing the two years: EoEC (reflect 2 and reflect4) being 8 and 7, respectively. For the light content: only 1 reflection was coded as craftsperson in reflect 3 and none in reflect 5 (see Table 36).

The number of reflections coded at technician and basic technician level was the same for most reflect meetings, except for reflect 4. In reflect 4, 20 reflections were coded as basic technician level (see Table 36).

Table 36 Levels of Discussed Reflections in Reflect Meetings

	Reflect 1	**Reflect 2**	**Reflect 3**	**Reflect 4**	**Reflect 5**
Craftsperson	5	8	1	7	0
Technician	3	4	5	4	7
Basic Technician	0	6	4	20	4
TOTAL	8	18	10	31	11

Before considering the plan meetings, I would like to explore reflect 4 in a little more detail. The comment I wrote in field notes for Reflect 4 was:" Discussion was robust and worthwhile."

The extract below (see Table 37), is an example from one such reflective episode. Teachers were reflecting on the difficulty learners were experiencing in linking the magnetic effect of an electric current causing the deflection of a compass needle. (see Appendix 16 Learner Notes from Cycle 4, Learner Activity EoEC, Year 2). In a previous activity, learners were given a picture of a small compass and asked what compasses are used for. Learners had completed an activity where they had noted that a magnetic field deflects a compass needle. They had also completed an activity where they noted copper wire was not magnetic. In this part of the lesson, learners observed when a compass is placed above a copper wire forming part of closed electrical circuit, the compass needle deflected. It was hoped learners would work with the knowledge from previous lessons and make the link that it was the magnetic effect of electric current causing the compass needle to deflect.

Table 37 Teacher dialogue exploring questions to ask learners, to link deflection of a compass needle with an EoEC (reflect 4).

	Teacher Utterance	**Level of Reflection**	
Jenny	*Ok now to get back to the types of questions you would ask. What would you ask the children when you go around to their groups?*	Initiated	Craftsperson
Luke	*Ok, so the magnetic effect, ok. So, what equipment are you using? Why are you using this equipment?*	Discussed	Craftsperson
Adele	*And how are you using it?*	Discussed	Craftsperson
Luke	*How, how would, how are we actually going to apply this to do something?*	Discussed	Craftsperson
Adele	*What does it prove?*	Discussed	Craftsperson
Luke	*What are you going to look for?*	Discussed	Craftsperson

In the extract I initiated the reflective episode. Luke and Adele threw ideas back and forth, each working off the suggestion of the other, trying to find questions, to ask learners that would allow learners to link the deflection of the compass needle, with an EoEC. Only part of the reflective episode is given, a total of 44 exchanges occurred. In this extract the teachers are moving beyond what the curriculum requires and are seeking to find questions that will guide learners to link the deflection of a compass needle to the magnetic field caused by the effect of an electric current.

More instances of teachers reflecting at the craftsperson level occurred during reflect meetings focused on the content EoEc. This may be because Luke was considered a content specialist for that topic, whereas none of the teachers were considered content specialists for the 'light' content. A second reason could be that the content EoEC provided more opportunities to interact with LPK, compared to the light content.

6.3.2 Plan Meetings

The number and levels of reflection coded for initiated reflective episodes and discussed reflections in 'plan meetings' are shown in Table 38 and Table 39 respectively. There was increase in the number of initiated reflective episodes when comparing the same content from one year to the next: EoEC (plan 2 and plan 4) and light (plan 3 and plan 5, see Table 38).

Table 38 Levels of Initiated Reflections in Plan Meetings

	Year 1		**Year 2**	
	Plan 2	**Plan 3**	**Plan 4**	**Plan 5**
Craftsperson	11	3	25	7
Technician	14	2	6	3
Basic Technician	0	0	4	2
TOTAL	25	5	35	12

Not only did the number of reflective episodes increase year on year, but so too did the level at which teachers reflected, for both content areas. Comparing the levels of reflections for initiated reflections for the content EoEC, from plan 2 with those of plan 4: of the 25 reflective episodes coded: 11 were at the craftsperson level with the remaining 14 initiated reflective episodes being coded as technician (see Table 38). This contrasts with plan 4: where 25 of the initiated reflective episodes were coded as craftsperson and the remaining 10 reflective episodes being coded either as technician or basic technician. For the light content, the number of initiated reflective episodes coded at the craftsperson level increased, from 3 craftsperson initiated reflective episodes in year 1 (plan 3) to 7 in year 2 (plan 5, see Table 38). No basic technician reflections occurred in Plan 3, whereas in year 2 (plan 5) 2 reflections were at the level of basic technician.

When comparing the total number of discussed reflections with the total number of initiated reflections, for the plan meetings, it is evident that the teacher participation increased with continued attendance at PLC meetings (see Table 39), as the number of discussed reflections increased year on year, when plan meetings were on the same content. Calculating the discussed reflections as a percentage of the number of initiated reflective episodes for a meeting gives a sense of teacher participation, as a teacher was only coded once during a reflective episode, regardless of how many contributions they made in the reflective episode. Teacher participation measured as a percentage of the discussed reflections to initiated reflective episodes are as follows: plan 2 64%, plan 3 220%, plan 4 149% and plan 5 150%.

Only 16 discussed reflections were coded in plan 2 compared to 25 initiated reflective episodes in plan 2 (see Table 38 and Table 39). This means at least 9 reflective episodes involved a single teacher raising a concern, where no other teacher participated. This contrasts with plan 3, where the numbered discussed reflections are more than double the number of initiated reflective episodes (see Table 38 and Table 39). For both plan 4 and plan 5 (year 2) the participation of teachers in reflective episodes is about one and a half times more than the number of initiated reflective episodes coded.

Table 39 Levels of Discussed Reflections in Plan Meetings

	Year 1		**Year 2**	
	Plan 2	**Plan 3**	**Plan 4**	**Plan 5**
Craftsperson	4	1	22	4
Technician	6	4	17	8
Basic Technician	6	6	13	6
TOTAL	16	11	52	18

The number of reflections coded for the same content (plan 2 and plan 4; plan 3 and plan 5) over the 2 years, not only shows an increase in the number of discussed reflections, but also an increase in the number of reflections coded at the craftsperson level. For EoEC content, (plan 2 and plan 4), the number of craftsperson discussed reflections increased from 4 in plan 2 to 22 in plan 4 (see Table 39). In plan 4 teachers were now concerned with improving learner conceptual understanding and less with curriculum completion. An increase in discussed reflections occurring at the levels of both technician and basic technician also occurred. With nearly 3 times as many technician reflective episodes and just over twice as many basic technician reflective episodes being coded (plan 2 and plan 4 see Table 39). Comparing this to the plan meetings focussed on the light content, (plan 3 and plan 5,) four times as many reflections were coded as craftsperson in the second year, with twice as many reflections being at the low technician level in year 2. However, the number of reflections at the level of basic technician reflective episodes, remained the same from year 1 to year 2 (see Table 39). The topic that was the focus of the meeting influenced teacher participation. Where there was a content specialist and where the topic provided more opportunities to explore LPK, teacher participation was higher during plan meetings, compared to plan meetings focused on the topic 'light', where none of the teachers were experts and where the content did not provide as many opportunities to unpack what learners already know. However, comparing meetings focused on the same topic showed that both teacher participation and the level at which teachers reflected increased from one year to the next.

Having looked at the how number of reflective episodes and level of reflections in the reflect and plan meetings changed over the two years, I continue to move my results to consider how individual teachers reflective practice changed over the two years they participated in PLC meetings, by considering their participation in meetings and their level of reflection.

6.4 Individual Level of Teacher Reflections

Since I am looking at my data through a socio-cultural lens, it is useful to get a sense of how individual teachers participated in meetings and what level they reflected as the study continued. By tracking their individual participation through the various meetings, it is possible to trace their path as they move through their ZPD. Secondly, by unravelling the data and digging deeper into individual teacher reflections it is possible to identify which teachers were more capable, and assisted their peers move through their ZPD, in what Kuusisaari (2014) referred to as symmetrical collaboration. I have chosen to discuss Luke's participation first, as he was the most experienced teacher in the group and was considered the expert on the content 'effects of electrical current', having been the school's senior electrical technology teacher for over 30 years. Luke took the lead in meetings focused on EoEC. I will discuss the reflective practices of the two inexperienced teachers: Kate and Adele's, followed by my own.

I am reluctant to discuss my reflective practice too much, as this is not a self-study, I wanted to participate as an equal with the teachers in my study. As this was my project, it is likely I was more motivated than the other teachers. Having said that, at the time of data collection I was unaware of how I would finally code my data and was not familiar with measuring various reflective levels. All teachers attended every meeting and were positive about the project throughout the two years. When no-one stepped up as leader with the light content, I was the one who took the lead. This is the reason for including my reflective practice in the results. I start discussing the results of individual teachers by reporting on Luke's reflective practice.

6.4.1 Luke

Even though Luke had 37 years teaching experience, he was eager to participate in the research. In Luke's first interview at the start of year one, when reminding Luke that he was free to withdraw from the project at any time his reply was:

Turn 7 *I think this activity of yours is going to be quite exciting. I am looking forward to it.*

Luke First Interview

Luke was an active participant in the first reflect meeting, as he initiated 11 reflective episodes and participated in another 2. This meant of the 16 reflective episodes that occurred in reflect 1, Luke did not participate in 3. Not only was he an active participant he took the lead in the first reflect meeting, (see Table 40, reflect 1) initiating two thirds of the reflective episode. Towards the end of reflect 1, having decided that the content we would focus on would be EoEC Luke offered to put activities together, for plan 2, with the following comment:

Turn 322 *Oh, that's excellent, I don't mind putting something together and then everybody just adds on to it. You can always add on to this*

Luke Reflect 1

Of the 16 reflective episodes that took place in reflect 1, Luke initiated 11, with 8 being coded craftsperson. Luke was also responsible for initiating many of the reflective episodes in in the plan meetings for the content EoEC for both years, viz. plan 2 and plan 4 (see Table 40). Most of these reflections were coded at the reflective levels: craftsperson and technician. Luke's reflective practice was slightly different when comparing reflect meetings with the same content. During reflect 2, Luke participated in 10 reflective episodes, only initiating 3 of these (see Table 40), albeit that they were at the craftsperson level. In year 2, Luke did not initiate any reflective episodes during reflect 4, although he did participate in 12 of the 14 reflective episodes (see Table 41).

Luke's reflective practice in meetings focussed on the light content showed a different result. In these meetings (plan 3, reflect 3, plan 5 and reflect 5) Luke initiated only 6 reflective episodes over the two years (see Table 40). Luke did not initiate any reflective episodes in plan 3 and only 1 in Plan 5, albeit at the craftsperson reflective level. When reflecting on the light content in year 1 (reflect 3), Luke initiated 2 of the six reflective episodes. Whilst in year 2, (reflect 5) Luke initiated 3 of the 5 reflective episodes.

Table 40 Luke: Levels of Teacher Initiated Reflective Episodes

		Year 1					Year 2			
		Reflect 1	Plan 2	Reflect 2	Plan 3	Reflect 3	Plan 4	Reflect 4	Plan 5	Reflect 5
Luke	Craftsperson	8	4	3		1	4		1	1
	Technician	3	5			1	2			
	Basic Technician						1			2
TOTAL		11	9	3	0	2	7	0	1	3

Towards the middle of reflect 2, Luke acknowledged that he is not a confident with the light content of work. In the excerpt below I ask the teachers to suggest questions we could ask learners to probe their prior knowledge concerning what they know about light. Luke replies: 'Here I fall apart.'

Turn 396 *Jenny* *As an introduction, so we need some like questions to get them going. On what their understanding of light is.*
Turn 397 *Luke* *But, here I fall apart.*
Turn 398 *Adele* *What?*
Turn 399 *Luke* *I have to reread this section every time I teach it.*

Reflect 2

Whilst Luke may not have initiated many reflective episodes focused on the light content, he was an active participant in most reflective episodes in both years. For instance, in year 1, (reflect 3), a total of 6 reflective episodes were coded: Luke initiated 2 of these reflective episodes (see Table 40) and participated in another 3 (see Table 41). Looking at the 3 reflective episodes where Luke's reflections were coded as 'discussed reflections', reflections were coded at each reflective level, viz basic technician, technician and craftsperson (reflect 3, see Table 41). Luke was a participant in all reflective episodes that took place in reflect 5: initiating 3 and taking part in discussions in the remaining 3.

Table 41 Luke: Levels of Teacher Discussed Reflections

		Year 1					Year 2			
		Reflect 1	Plan 2	Reflect 2	Plan 3	Reflect 3	Plan 4	Reflect 4	Plan 5	Reflect 5
Luke	Craftsperson	1	2	3		1	8	3		
	Technician	1	1	3	1	1	3	4	3	2
	Basic Technician			1	4	1	2	5	1	1
TOTAL		2	3	7	5	3	13	12	4	3

Table 42 shows how Luke's participation in reflective episodes changed over the two years. I have represented the results as a percentage, as this allows comparisons from one meeting to another to be made. I calculated the percentage participation in reflective episodes by dividing the number of reflective episodes a teacher participated in, by the total number of reflective episodes for a meeting. For instance, Luke participated in 6 reflective episodes in plan 5 (initiating 3 and discussing 3), so his participation in reflective episodes was 100% for plan 5.

Table 42 Luke: Participation in reflective episodes as a % of the number of reflective episodes.

Year 1					**Year 2**			
Reflect 1	**Plan 2**	**Reflect 2**	**Plan 3**	**Reflect 3**	**Plan 4**	**Reflect 4**	**Plan 5**	**Reflect 5**
81	48	56	100	83	57	86	42	100

The table highlights Luke's active participation in reflective episodes, taking part in over 80% of the reflective episodes in 5 meetings. Comparing Luke's participation in each type of meeting, plan vs reflect, for each content area, year on year, in all cases, but one instance, there was an increase in participation: plan 2: 48% and plan 4: 57%; reflect 2 56% and reflect 4 86%, plan 3 100% and plan 5 42%; reflect 3 83% and reflect 5 100%. The only decline in participation, year on year occurred in the plan meetings for light: Luke participated in all reflective episodes, in year 1 (plan 3), this dropped to 42% participation in year 2 (plan 5).

Many of Luke's utterances particularly in reflect and plan meetings concerned with the content EoEC, were coded at the craftsperson level, as Luke not only predicted alternative conceptions learners hold on to, he was also able to identify problems with practice and recommended how to remedy these. An example of one such instance occurred during plan 4, where Luke recognised that teachers needed to explore the relationship between magnetic fields and deflection of a compass needle (see Table 43).

Luke initiated a reflective episode by suggesting a question teacher could ask learners: 'how would you use a compass?' Adele interrupts and offers 'magnetism in a compass'. A discussion between the teachers starts, and Luke suggests teachers ask learners: 'Name two methods to see if there's a magnetic field'.

Table 43 Teacher Dialogue and coding of level of reflection during Plan 4

		Level of reflection	**Explanation of coding**
Luke	*We must include here, compass. How would, how would you...*	Technician	Learners struggle linking magnetism to deflection of a compass needle.
Jenny	*Do they?*		
Luke	*How would you see ...*		
Adele	*Magnetism in a compass? Ja.*		Suggests a question for learners to make link.
Luke	*Ja.*		
Adele	*What does a compass do?*	Craftsperson	Refines her question.
Jenny	*Explain what is meant by a magnetic...*	Craftsperson	Bounces back a question.
Luke	*Ja. We must maybe see: "How would you be able to, how would you be able to see. Name two methods to be able to see if there's a magnetic field."*	Craftsperson	Asks directly about a magnetic field: how you would know if one is present.

It is interesting that even though Luke designed most of the EoEc worksheet most of the questions he asked were concerned with factual recall, definitions and labelling of apparatus. Few of Luke's questions were designed to probe learner understanding.

When it came to the light content, where Luke did not consider himself an expert, he initiated fewer reflective episodes in meetings concerned with this topic. Luke remained an active participant in the reflective episodes, contributing to discussions (see Table 41).

Luke was an active participant in all reflect and plan meetings, over the two years. However, in the reflect and plan meetings where Luke was an expert, he initiated many reflective episodes, with his most frequent level of reflection being coded craftsperson. Luke participated in reflective episodes, even those he did not initiate. When it came to the light content where Luke was not considered an expert, whilst he participated in most of the reflective episodes, he initiated far fewer of the reflective episodes.

By tallying the totals of the teachers' levels of reflection for initiated reflective episode reflections with discussed reflections (see Figure 8), an overall indication of the reflective levels teachers reflected at throughout the project is clearer. Luke's reflections were coded at all reflective levels, throughout the project, with many being coded at the craftsperson level. It was only during plan 3, where no instance of Luke reflecting at the 'craftsperson' level occurred.

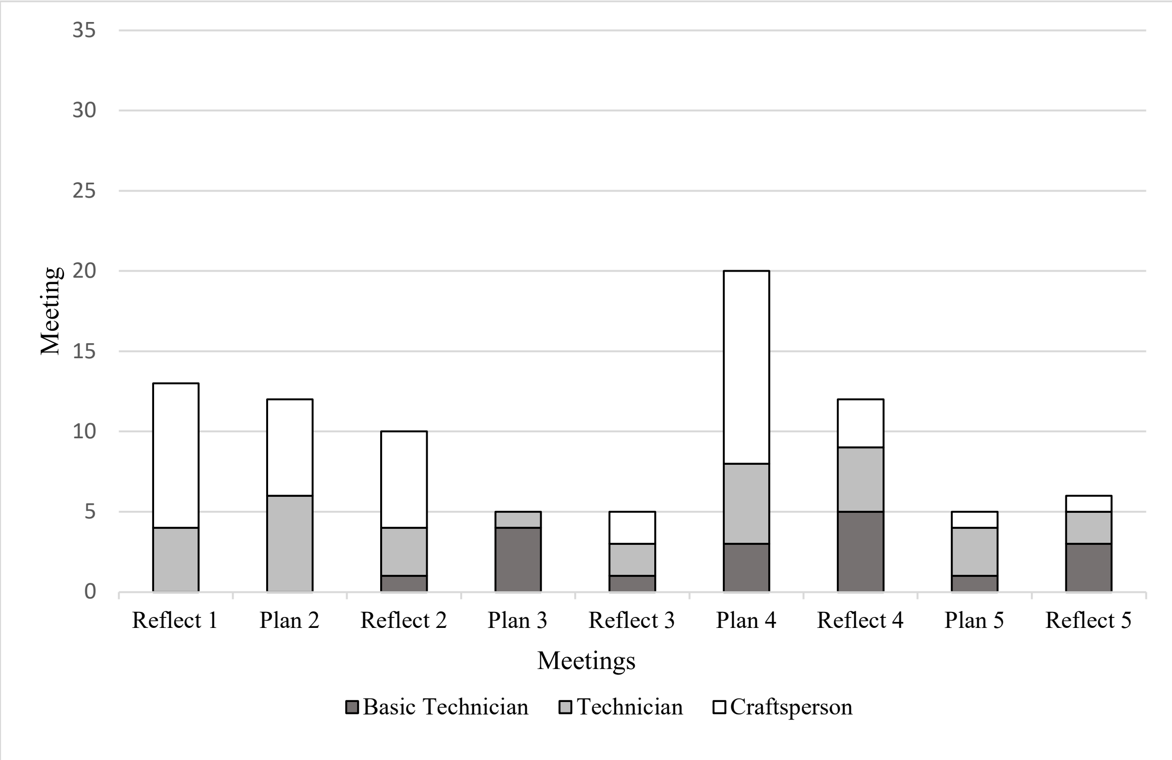

Figure 8 Luke: Combined Level of Reflections: Initiated reflective episodes and discussed reflections

Luke was asked to reflect on his experiences on working in a PLC in his interview at the end of each year. At the end of year 1, Luke spoke of how he had gained pedagogic knowledge and little content knowledge.

Luke	*I've learnt a lot actually. Just, I learnt a lot this year by doing it. I don't know how the other people feel, but I'm very happy with it.*
Jenny	*And when you say you learnt a lot in terms of content? Or how to teach?*
Luke	*Not really content, but what, how everybody else also thinks. And you know sort of and, and the ways of doing things and sort of things I wasn't quite sure of. Sort of, it was corrected for me.*

Luke Interview End of Year 1

At the end of year 2, Luke commented how his content knowledge, particularly referring to electrolysis had improved. Being the expert on EoEC, this was unexpected. The excerpt below Luke acknowledges this improvement:

But I gained a lot. I mean my chemical stuff has improved by leaps and bounds since we've actually got into this stuff.

Luke Interview Year 2

Luke's reflections in year 2, continued to acknowledge gains in his pedagogic knowledge as in the excerpt below he speaks of being exposed to different ways of teaching which he hadn't thought of.

Different perspectives. Different ways of doing things. Like then you'll come up with something and Adele will come up with something. And somebody else will, will come up with something. You think: 'You know I haven't tried that!'

Luke Interview end of year 2

Luke also spoke of being supported by members of the PLC; where teachers assisted each other and valued the safe and trusted space for learning had been created. In the excerpt below Luke speaks of feeling comfortable enough to ask for assistance where he feels unsure about an issue.

What I have taken out of it, we've actually a good, good group. We, we've quite a close group, I think. And if you need information, if you need help from somebody, you can go to anybody in our group and they will help you out with it.

Luke Interview end of year 2

Luke was attentive to alternative ways of teaching and was keen to improve his pedagogic knowledge. He participated in most reflective episodes, initiating many. Luke took the lead in meetings that were focussed on EoEC, where his content and PCK were sound. From the first meeting, reflect 1, Luke was able to initiate reflective episodes, and this at the craftsperson level of reflection. This was not true for meetings that were focussed on the light content of work. Whilst Luke participated in many reflective episodes focused on light, he did not initiate many. Luke's reflections were at a lower level for the light content of work, compared to the EoEC content.

I continue looking at the results by unpacking reflective practice of the inexperienced teachers starting with Adele and then Kate.

6.4.2 Adele

Adele the inexperienced, Life Sciences teacher, did not initiate any reflective episodes in the first reflect and plan meetings (reflect 1 and plan 2), (see Table 44). The first reflective episodes she initiated was in reflect 2 (see Table 44). The next time Adele initiated a reflective episode was in reflect 4 (see Table 44). Two of the reflect episodes Adele initiated in reflect 2 were coded as craftsperson and the other as basic technician. When comparing the level at which Adele reflected in reflect 4 (EoEC year 2) with reflect 2 (EoEC year1), of the three reflective episodes she initiated, none were at the craftsperson level: one was at the technician level and the remaining two were coded basic technician (see Table 44). Adele did not initiate any reflective episodes when planning the EoEC content in both years (plan 2 and plan 4).

When it came to meetings focussed on the light content (cycles 3 and 5) it was only in plan 5 where Adele initiated two reflective episodes: one at the craftsperson level and one at the technician level (see Table 44).
Whilst Adele may have initiated few reflective episodes, she was an active participant in all reflect and plan meetings (see Table 45 and
Table 46). Adele participated in 3 of the 16 (19%) reflective episodes in reflect 1. This compares with 4 of 25 (16%) plan 2. In reflect 2, Adele initiated 3 reflective episodes and was involved in the discussion of another 4, in total she participated in 7 of 18 (39%) reflective episodes.

Table 44 Adele: Levels of Teacher Initiated Reflective Episodes

		Year 1					Year 2			
		Reflect 1	**Plan 2**	**Reflect 2**	**Plan 3**	**Reflect 3**	**Plan 4**	**Reflect 4**	**Plan 5**	**Reflect 5**
Adele	Craftsperson			2					1	
	Technician							1	1	
	Basic Technician			1				2		
	TOTAL	0	0	3	0	0	0	3	2	0

In the third cycle, though Adele did not initiate any reflective episodes, she was an active participant: 3 of the 5 reflective episodes (60%) plan 3, and 2 of the 6 reflective episodes (33%) reflect 3. In plan 4, Adele participated in, 17 of 35 reflective episodes (49%). During reflect 4, Adele initiated 3 reflective episodes and participated in the other 11 reflective episodes, she therefore was a participant in all 14 reflective episodes (100%). During plan 5, Adele initiated 2 reflective episodes and made contributions to another 6 reflective episodes. She therefore participated in a total of 8 of the 12 (67%) of the reflective episodes. During reflect 5, Adele did not initiate any of the 6 reflective episodes. However, she was a participant in 5 (83%).

Table 45 Adele: Participation in reflective episodes as a % of the number of reflective episodes.

Year 1					Year 2			
Reflect 1	**Plan 2**	**Reflect 2**	**Plan 3**	**Reflect 3**	**Plan 4**	**Reflect 4**	**Plan 5**	**Reflect 5**
19	16	39	60	33	49	100	67	83

Whilst there is an overall increase in Adele's participation in reflective episodes as she attended more reflect and plan meeting, starting from 19% participation in reflective episodes in reflect 1, to participating in 83% reflective episodes in reflect 5. The increase in participation was not linear. For instance, Adele's participation in reflect 1 was at 19%, whilst in plan 2 this dropped to 16%. Further, in reflect 4 Adele participated in all the reflective episodes (100%). This was the only meeting where she participated in all reflective episodes.

When comparing the same type of meeting with the same content year on year, in each instance Adele's participation was higher (see Table 45): EoEC: plan 2 (16%) and plan 4 (49%), reflect 2 (39%) and reflect 4 (100%). Light: plan 3: (60%) and plan 5 (67%), reflect 3 (33%) and reflect 5 (83%).

Table 46 Adele: Levels of Teacher Discussed Reflections

		Year 1					Year 2			
		Reflect 1	**Plan 2**	**Reflect 2**	**Plan 3**	**Reflect 3**	**Plan 4**	**Reflect 4**	**Plan 5**	**Reflect 5**
Adele	Craftsperson	2		3	1		4	2	1	
	Technician	1	4		1	1	7		4	3
	Basic Technician			1	1	1	6	9	1	2
	TOTAL	3	4	4	3	2	17	11	6	5

I turn my discussion to consider the level at which Adele reflected, in the reflective episodes she participated in, but did not initiate. I will compare like meetings for the same content. During plan 2 (EoEC, year1), all 4 of Adele's reflections were coded as technician. However, no clear pattern emerges when looking at the level at which Adele reflected over the two years (see
Table 46 and Figure 9).

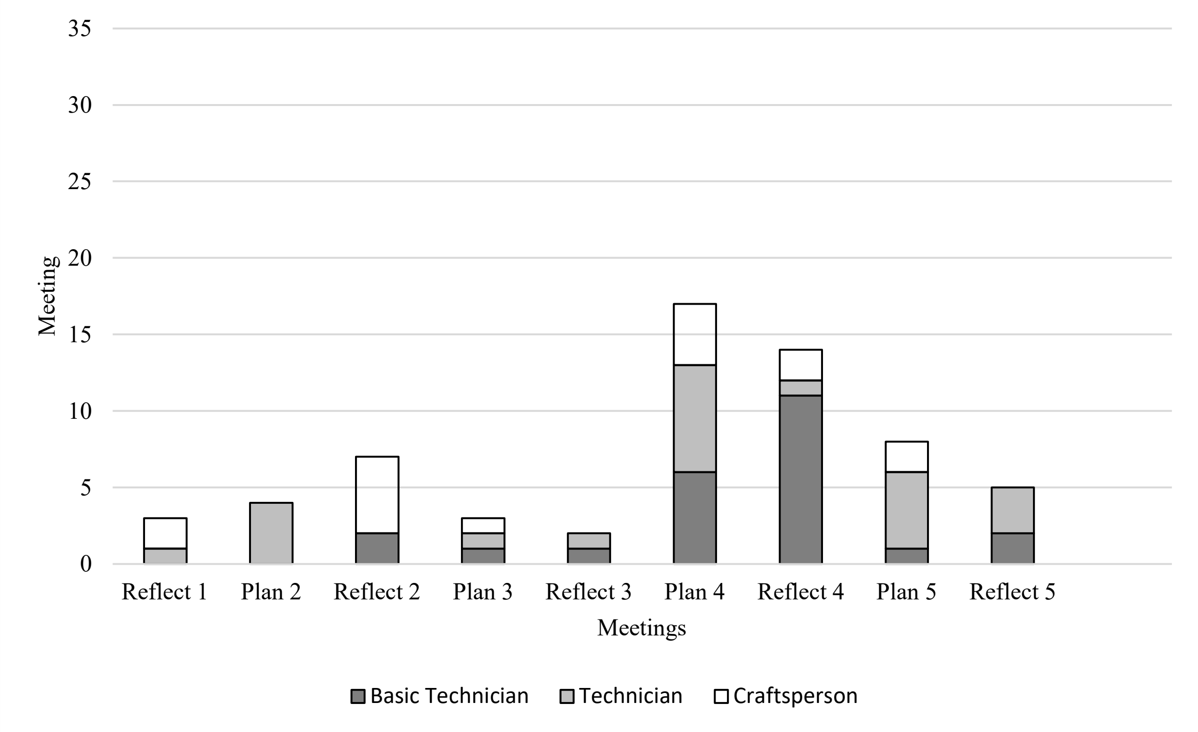

Figure 9 Adele: Combined Level of Reflections: Initiated reflective episodes and discussed reflections

Adele was able to reflect at the craftsperson level from the first meeting, reflect 1. Of the 9 meetings that formed part of the project, Adele's level of reflection was coded at craftsperson level in all but 3 meetings. I have included an excerpt from a reflective episode where Adele reflected at the craftsperson level from reflect 1.

Turn 66	Jenny	Craftsperson	*You see here, now this is my concern ...you've got them all thinking. But how do we get passed, and I don't know what the answer is ... to stopping us saying "so now you give me the answer and you give me the answer." Do you know what I'm saying?*
Turn 67	Adele		*Write it down*
Turn 69-79	Adele	Craftsperson	*You know what's nice, and actually, Denae, gave me, er, er a good idea, the one day. You just, you just take a piece of paper and you laminate it, a white piece of paper. And each kid gets a white piece of paper. And then they write down the answer on that on that blank laminated page, in um whiteboard marker. It can um come off easily. And then they all stick up the answers in the air.*

Reflect 1

In this reflective episode, I raise a concern on how to manage interacting with all learner responses efficiently. As asking individual learners one at a time becomes tiresome. In this extract Adele suggests that each learner have a surface on which to write their answer and then hold these up. In this way, the teacher is quickly able to see learners' responses.

Comparing the level at which Adele reflected, year on year, per content area and type of meeting the following was found: EoEC, plan 2 all of Adele's reflections were coded as technician, compared to plan 4, where 4 reflections were coded as craftsperson, 7 technician and 6 as basic technician (see Figure 9). Not only did Adele's participation increase from plan 2 to plan 4, so too was the level at which she reflected. However, when comparing reflect meetings focussed on the same content (reflect 2 and reflect 4), 1 less reflective episode was coded as craftsperson in year 2. No technician reflections were coded in either year (reflect 2 and reflect 4). Yet 9 basic technician reflections were coded in year 2 (reflect 4) compared to 1 on year 1 (reflect 2 see Figure 9).

When comparing like meetings focussed on the 'light' content, the following was found; one of each level of reflection was coded in year 1 (plan 3), this compared to 1 craftsperson, 4 technician and 1 basic technician in year 2 (plan 5). A similar trend was found when comparing the reflect meetings, in that there was an increase in the number of technician reflections coded: 1 in year 1 (reflect 3) and 3 in year 2 (reflect 5). One more basic technician reflection was coded in year 2 (reflect 5) compared to year 1 (reflect 3). Adele did not reflect at the craftsperson level in either light reflect meetings (reflect 3 and reflect 5, see Figure 9).

Whilst Adele was an active participant in all meetings, her participation in reflective meetings, increased in year 2, compared with year 1. Adele could reflect at the craftsperson level from the first meeting. As her participation in meetings increased so there was an increase in the number of reflections coded at the basic technician and technician levels. Participation in meetings and the level of reflection was dependent on content, with Adele participating more in the meetings focused on EoEC compared to light. In these meetings her reflections were at a higher level compared to the light meetings. There was a slight increase in the number of reflective episodes Adele initiated in the second year.

When asked to reflect on her experiences whilst working within a PLC at the end of each year, Adele's reflections in both years included the value she placed on learning from peers, particularly Luke, with the EoEC content.

> *I've seen Luke in a whole new light. Cause, um, the amount of, or the wealth of knowledge he has, is, is quite amazing. Um, and he taught me quite a few things, I was, I was duly impressed.*

Adele interview end of year 1

In the first year, Adele acknowledged she was an inexperienced teacher and appreciated the support offered by the group as well as the opportunities to reflect on the content and experiences.

> *Um, but I also think that it was nice that we could reflect what was going on in our classrooms as well. And I think, you know, I am only, this is only my third-year teaching, but you know sometimes you feel like, 'Oh my gosh am I doing things right? Is this going well? What's happening?' Um, and to be able to come and talk about what's actually happening in your classroom, I think it is also a destressing, in a way.*

Adele interview end of year 1

When asked about her experiences on working in a PLC, at the end of the project Adele spoke on gains in her pedagogic knowledge as how she felt she was more mindful of the questions she asked and learner responses.

> *Um, it's made me more aware of the questions I ask. And the responses I get*

Adele Final Interview

Adele also mentioned how her understanding in creating worksheets had improved and she spoke of the support and care that had developed between the teachers, which extended to outside meeting times.

> *Other than content knowledge, and a appreciation for worksheets that wasn't there before, um, I think, I gained a better understanding of the people I work with as well. Um, I know Luke a lot better now. I am not going to lie. Um, Luke actually came to my classroom the other day, I think it was last week Friday, he just came to say "goodbye." He was walking past, and he walked in to so "goodbye." And we had a long conversation. And that wouldn't have happened if we hadn't spent time together. And I think that makes a better working environment. When you can talk and relate to each other. And you can build those relationships with each other*

Adele Final Interview

Adele's participation in successive PLC meetings focused on reflecting how teachers interact with LPK, increased when comparing her participation in the first year with her participation in meetings in the second year. From the first meeting Adele was able to reflect at a craftsperson level. The increase in participation and the level at which Adele reflected was not linear. It was dependent on the content, with Adele participating more in the meetings focussed on EoEC. More of Adele's reflections were at the level of craftsperson for the content EoEC compared to the light content. Adele acknowledged gains in both content and pedagogic knowledge by attending PLC meetings. In these meetings she was given an opportunity to reflect and a space was created where peers shared their experiences on teaching the same content using the same activities. Adele valued the wealth of expertise Luke so freely shared with the group. To this end Adele recognised the importance of establishing relationships between members of the PLC, thereby ensuring a trusted environment is created.

6.4.3 Kate

Kate's participation in reflective episodes in reflect 1, was low. Of the sixteen reflective episodes, Kate contributed to only one, and this was at the technician level (see Table 49).

It was not until the third PLC meeting (reflect 2) where Kate initiated her first reflective episode and then did so at the craftsperson level of reflection (see Table 47). During this reflective episode, Kate reflected on why some learners could not build an electromagnet, even though many learners had claimed they had done so in Grade 7 Technology lessons. Kate suggests a reason for this was that not all learners were active participants when the electromagnet was built the previous year. In grade 8, it was unlikely that the groups would have the same learners, now the passive participants from Grade 7 had to figure out how to build an electromagnet as they could not rely on their previous group members. The excerpt is given below:

> *I think what probably happened is that, they were split up into groups in Technology and they built their electromagnet. And you will find that probably one or two kids actually participated in building the magnet.*
>
> *And then they were split up again, and unlucky for them, the kids who actually built the magnet, weren't in their group anymore. So, they had to figure it out on their own*
>
> Kate Reflect 2

Kate did not initiate any reflective episodes in either the plan or reflect meetings focussed on light in year 1 (see Table 47, plan 3 and reflect 3). However, in year 2 of the study Kate initiated three reflective episodes during plan 4 and one during reflect 4. With meetings focussed on the light content Kate only initiated reflective episodes during plan 5 and none during reflect 5 (see Table 47). These were the only reflective episode she initiated for the light content in the four meetings in the 2 years, both at the craftsperson level. Over the two years Kate initiated seven reflective episodes: four of these were at the craftsperson level. Kate was mindful of the reflective episodes she initiated, thinking carefully what she was initiating. A second observation from this data, is that Kate only initiated one reflective episode in year 1. In year 2, this increased, as Kate initiated 6 reflective episodes.

Table 47 Kate: Levels of Teacher Initiated Reflective Episodes

		Year 1					Year 2			
		Reflect 1	**Plan 2**	**Reflect 2**	**Plan 3**	**Reflect 3**	**Plan 4**	**Reflect 4**	**Plan 5**	**Reflect 5**
Kate	Craftsperson			1				1	2	
	Technician						1			
	Basic Technician						2			
	TOTAL	0	0	1	0	0	3	1	2	0

Whilst Kate initiated few reflective episodes, she was an active participant in many reflective episodes. She participated in at least one reflective episode in all meetings (see Table 48). Kate's lowest level of participation in reflective episodes was in reflect 1, and her highest during plan 3. When looking at her participation in reflective episodes meeting to meeting, there is no trend evident, other than there was an increase in participation from meeting to meeting for the first four meetings, reflect 1 (6%) to plan 3 (60%). Following plan 3, Kate participated in about half the reflective episodes for the last 5 meetings, bar plan 5 where she only participated in a third of the reflective episodes (see Table 48).

Table 48 Kate: Participation in reflective episodes as a % of total number of reflective episodes.

Year 1					Year 2			
Reflect 1	**Plan 2**	**Reflect 2**	**Plan 3**	**Reflect 3**	**Plan 4**	**Reflect 4**	**Plan 5**	**Reflect 5**
6	16	22	60	50	57	50	33	50

Comparing year on year with the same content meeting, Kate's participation for the content EoEC, increased: plan 2 16% and plan 4 57%, reflect 2 22% and reflect 4 50%. However, there was a decline in Kate's participation in reflective episodes when planning the light content: Plan 3 60% compared to 33% during plan 5. Kate participated in 50% of the reflective episodes in both 'light' reflect meetings (reflect 3 and reflect 5).

I have combined data from those reflective episodes which Kate initiated with data on her participation in reflective episodes which she did not initiate, as this shows how the level at which Kate reflected changed from meeting to meeting, and year to year (see Figure 10).

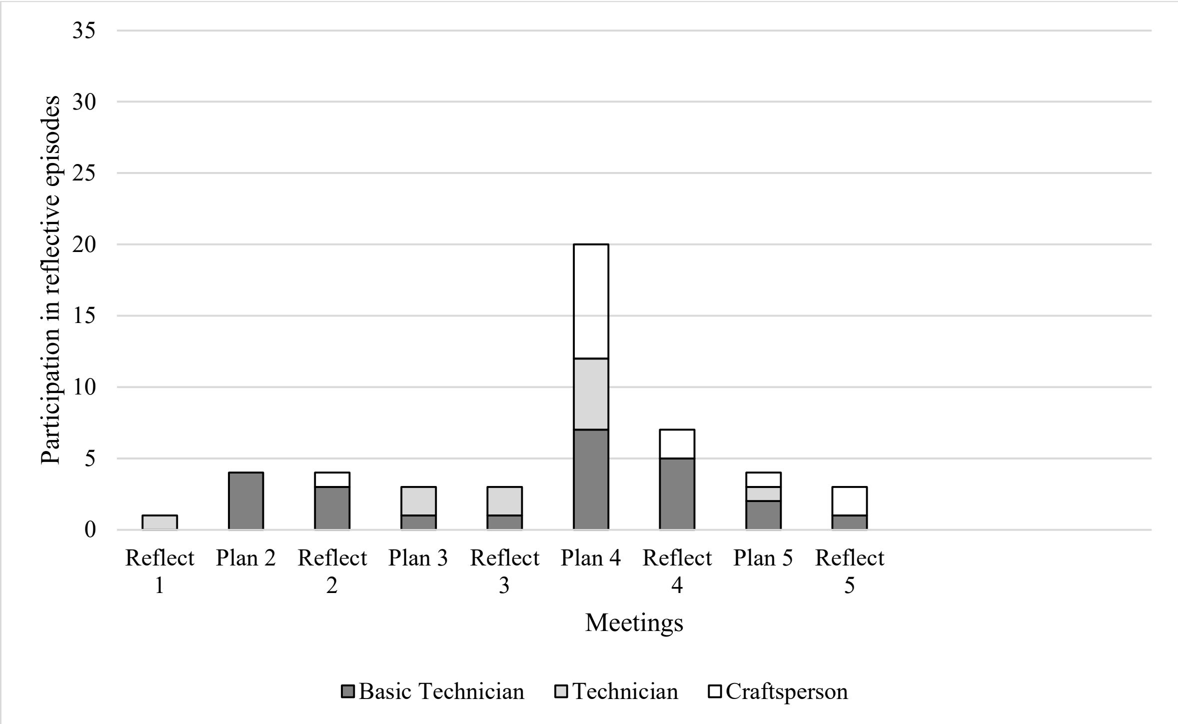

Figure 10 Kate: Combined Level of Reflections: Initiated reflective episodes and discussed reflections

In the first year of the study through all the plan and reflect meetings, Kate's participation was low, participating in fewer than 5 reflective episodes per meeting. The greatest number of reflective episodes she participated in was plan 4, where she participated in 20 reflective episodes (see Figure 10). This was the meeting where the greatest number of 'craftsperson' reflections occurred. In every meeting in the second year, Kate reflected at least once at the craftsperson level. This contrasts with the first year, where this happened once, in plan 2.

I turn my results discussion to consider the level at which Kate reflected in reflective episodes that she did not initiate by comparing the same meeting (reflect or plan) with the same content, year on year (see Table 49).

Table 49 Kate: Levels of discussed reflections

		Year 1					Year 2			
		Reflect 1	Plan 2	Reflect 2	Plan 3	Reflect 3	Plan 4	Reflect 4	Plan 5	Reflect 5
Kate	Craftsperson						8	1	1	
	Technician	1			2	2	4		1	
	Basic Technician		4	3	1	1	5	5	2	1
	TOTAL	1	4	3	3	3	17	6	4	1

Not only did Kate's participation in reflective episodes increase from 16% in year 1 of the EoEC content (plan 2) to 57% in year 2 (plan 4) (see Table 47), but so too did the level at which she was reflecting. This is evident in the 4 reflective episodes Kate participated in, in plan 2 being at the basic technician level, compared to eight craftsperson and four technician levels of reflection during plan 4 (see Table 49). Similarly, for the reflect meetings, year on year Kate's participation and level at which she reflected was higher when comparing reflect 2 with reflect 4.

When comparing meetings focused on the light content: Kate's participation in reflective episodes was much the same when comparing plan 3 vs plan 5 (see Table 49), whilst one more discussed reflection was coded at the technician level in plan 3, Kate reflected at the craftsperson level in year 2 (plan 5). where Kate reflected at the craftsperson level. Like Adele, Kate's participation and level at which she reflected decreased during reflect 5 (1 reflective episode, basic technician level) compared to reflect 3 (3 reflective episodes, 2 technician (reflect 3) and 1 basic technician level (reflect 5).

In Kate's final interview, when asked how, if at all, she found any value in attending PLC meetings, Kate highlighted how peers had assisted her improve her pedagogic knowledge. The excerpt below is taken from Kate's interview at the end of Year 2.

> *I think it made me more confident in in this section. I think often times, where, if you have the content, you need the confidence to teach it and I think with this, you go over it and over it again. And you hear how other, other people explain it. And then you realize, 'Ok, I can do this now.'*
>
> Kate Final Interview Year 2

Kate's participation in reflective episodes increased with attendance at the first four PLC meetings. Kate's participation in the next 5 meetings (plan 3 through to plan 5) remained at around 50-60% participation in reflective episodes. Kate's participation was highest during plan 3 and plan 4. With continued attendance at PLC meetings the level at which Kate was reflecting increased, with more reflections being coded at the craftsperson level in year 2. Kate started to initiate reflective episodes as the project continued.

Of all the participants, Kate's participation in reflective episodes was the least. Kate was inexperienced, teaching a topic that was not her expertise. She was committed to the project and participated in discussions when she felt confident. Her participation increased as the study continued.

6.4.4 Jenny

Before unpacking my reflective practice, I am going to be upfront about my position during data collection. Throughout the time data were collected I was conscious that I would have some advantages over the other participating teachers. Whilst I was aware of the cyclical nature of action research and the purpose for using this research design was to explore how to teachers interact with LPK, it was only after all data had been collected that a decision was made on how to code the reflective practice of teachers. I was therefore unaware that data would be sorted into reflective episodes or that the level of reflection would be coded. I was mindful that this was my project, suggesting I would lead the project in some way, and that I would be motivated throughout the time data were collected.

I scheduled all reflect and plan meetings and was determined to explore problems encountered and develop strategies, as well as activities that would allow teachers to interact with LPK in a meaningful way. This is the likely reason that I initiated so many reflective episodes in each of the meetings, with many being at the craftsperson level (see Table 50).

I initiated reflective episodes in all meetings, at varying levels of reflection. Where I initiated many reflective episodes, (plan 4 see Table 50), there was an increase in the number of reflections being coded craftsperson. The most common level of reflection I was coded at was craftsperson. I do need to emphasize that this was my project, and I was motivated, probably more than the other teachers to address problems I had identified, both in my class and the other teachers' classes.

Table 50 Jenny: Levels of Teacher Initiated Reflective Episodes

		Year 1					Year 2			
		Reflect 1	**Plan 2**	**Reflect 2**	**Plan 3**	**Reflect 3**	**Plan 4**	**Reflect 4**	**Plan 5**	**Reflect 5**
Jenny	Craftsperson	5	7	6	3	1	21	7	3	1
	Technician		9	2	2	1	3	1	2	1
	Basic Technician			3		2	1	2	2	1
	TOTAL	5	16	11	5	4	25	10	7	3

During reflect 1, I initiated 5 reflective episodes (see Table 50). This contrasts to the 11 reflective episodes that Luke initiated in reflect 1 (see Table 40). Luke was responsible for initiating 69% of the reflective episodes in reflect 1, whereas I initiated 31% (see Table 51). Except for this meeting, reflect 1, I initiated at least half the reflective episodes in all other meetings.

Whilst Luke took the lead initiating many reflective episodes in meetings focussed on the content EoEC (reflect 1, plan 2 and reflect 2), when it came to the light content, I was the only teacher who came prepared with possible activities and had read up on alternative conceptions learners may have with the 'light' content. This is evident in plan 3, where the five reflective episodes that occurred during the meeting I initiated (see Table 50). The extract below (from plan 3) is an example of one such reflective episode, here I highlight possible alternative conception learners may have regarding the light content. In this extract I explain to Adele, Kate and Luke that I have read up on some alternative conception's learners may have with understanding how light travels to the eye (Guesne, 1985). In Turn 53, I refer to a document titled 'Content map for the Natural Sciences in GET, showing the links to the FET sciences curriculum' given to teachers many years previously where alternative conceptions learners may have, are listed. The document is divided into various layers, detailing aspects of the curriculum. Even though much of the document is out of date, since it was based on the previous OBE curriculum, it is a useful resource as it states possible alternative conceptions learners may have with various content areas and supplies the references to the studies making the claims. This document was available to all teachers in our shared 'Drop Box' folder. In this extract I am referring to Activity 2 in the learners' light notes (see **Appendix 14**).

Turn 53	Jenny	*Then, this one here, cause I read a little bit about the misconceptions in, remember those old layers that we had. Layer 1, layer 2, layer 3? In layer 3, I must actually print it, it's in drop box anyway. Um, it gives you a list of all the research that has been done, on all the, the work and what the misconceptions are. And what the children think, you see because the light is going from your eyes to the book..*
Turn 54	Adele	*Hhhmmm.*
Turn 55	Jenny	*Not from the book up.*
Turn 56	Luke	*Ok.*
Turn 57	Jenny	*Ok, so that's why I did this picture. So, 'Mpho and Steve made the following drawing. They wrote the following about the drawing: The light shines on the book.' That they don't have a problem with because they can see the light coming down.*
Turn 58	Luke	*Ja.*
Turn 59	Jenny	*' Smiley looks at the book, and sees the book, because the light is shining on it.' So, 'what part of the diagram is correct?'*
Turn 60	Adele	*Ja.*
Turn 61	Jenny	*'And fix the part of the diagram that is incorrect. Explain why you changed the diagram.' This is all like their prior knowledge stuff.*
Turn 62	Luke	*But this is nice, because I had to look at this and see what are you trying to tell us there? And I've realized that they don't understand.*

Plan 3

This contrasted with how teachers participated in reflective episodes the following year when planning the same content (plan 5). In plan 5 all teachers initiated reflective episodes, and the number of reflective episodes I initiated decreased to 58% (plan 5 see Table 51).

Table 51 Teacher initiated reflective episodes as a % of the total number of reflective episodes.

	Year 1					Year 2			
	Reflect 1	**Plan 2**	**Reflect 2**	**Plan 3**	**Reflect 3**	**Plan 4**	**Reflect 4**	**Plan 5**	**Reflect 5**
Luke	69	36	17	0	33	20	0	8	50
Adele	0	0	17	0	0	0	21	17	0
Kate	0	0	6	0	0	9	7	17	0
Jenny	31	64	61	100	67	71	71	58	50
	100	100	100	100	100	100	100	100	100

I continue to discuss my participation reflective episodes over the two years, by combining the reflective episodes I initiated with those where I participated, as a percentage of the total number of reflective episodes. In reflect 1 I participated in 7 of the 16 reflective episodes (44%, see Table 52). For meetings where the focus was on EoEC (cycle 2 and cycle 4), I participated in 80% of the reflective episodes. Meetings focussed on the light content show a different pattern. In the first year (cycle 3) I was a participant in all the reflective episodes, whereas in year 2, this decreased slightly to 83% (see Table 52).

Table 52 Jenny: Participation in reflective episodes as a % of total number of reflective episodes

Year 1					Year 2			
Reflect 1	**Plan 2**	**Reflect 2**	**Plan 3**	**Reflect 3**	**Plan 4**	**Reflect 4**	**Plan 5**	**Reflect 5**
44	84	83	100	100	86	86	92	83

To get an overall sense of the level at which I reflected over the two content years, I have combined data for the same session together, i.e. I have added the level at which I reflected when initiating a reflective episode with the data for those reflective episodes where I was involved in the discussion (see Figure 11). More than half of my reflections in the content area EoEC, were coded at the craftsperson level (see Figure 11). For the light content in both years, not only were the number of reflective episodes fewer, but so too was the level at which I reflected (cycles 3 and 5, see Figure 11).

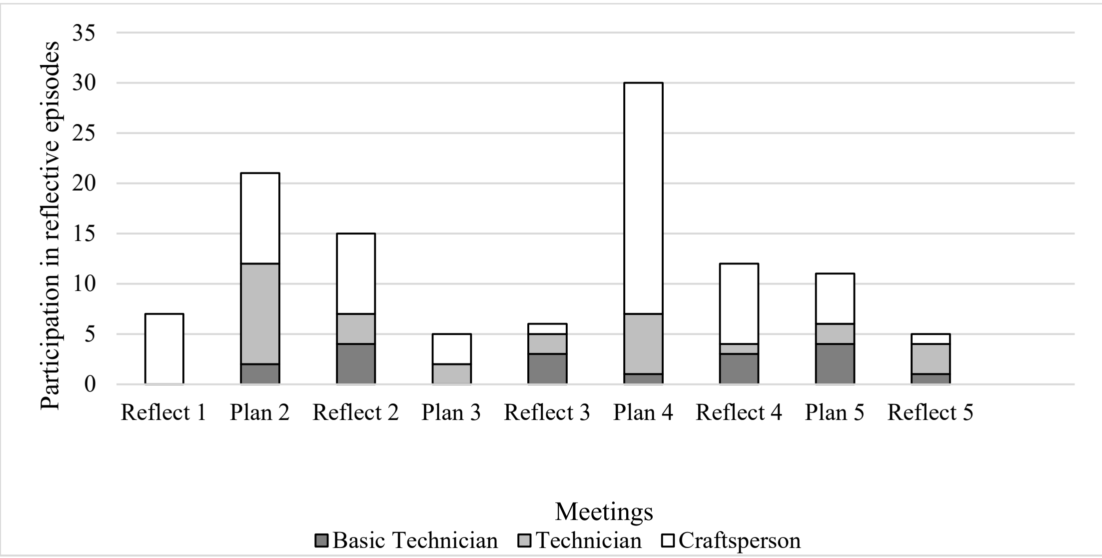

Figure 11 Jenny: Combined Level of Reflections: Initiated reflective episodes and discussed reflections.

Few of the reflective episodes I participated in were coded at the low basic technician level of reflection. A probable reason for this was that this was my research project, and I was motivated to identify and find solutions to problems with working with LPK. Further, I was the only teacher to observe all teachers in their classrooms and was aware of what had occurred four classrooms and not just the class I taught. This gave me more opportunity to reflect on what was taking place in all classes and not only mine. I was aware of the advantage I gained by being in all the classes. I made the following statement towards the end of the Adele's interview at the end of year 1, when discussing the value of working collaboratively on the project, with reference to the difficulty of constructing pin hole cameras:

> *I found that very useful, because I think we all have our own strengths and its nice when... I mean I had the privilege of being in everybody's class. So, I could see what Luke did, and I could see what Kate did. And I, and I struggled myself. I did struggle myself. My class did it twice. So, I could help you. But, I, I mean, I pretty much could see what everybody was doing and kind of figure it out. Which I found very beneficial.*
>
> *Jenny (Adele interview end of Year 1)*

I was an active participant in reflective episodes that I did not initiate (see Table 53). I was able to reflect at a craftsperson level from the first meeting. In meetings focused on EoEC in the first year (cycle 2) 'discussed reflections' were coded at all levels of reflection. This compared to year 2 (Cycle 4) where only 1 reflection was at the low basic technician level.

None of my 'discussed reflections' in light meetings (plan 3 and reflect 3) in the first year were at the craftsperson level (see Table 53). Comparing this to the second year (plan 5 and reflect 5), not only had the number of discussed reflections increased so too has the level at which I reflected, with 2 reflective episodes being coded craftsperson.

Table 53 Jenny: Levels of Teacher Discussed Reflections

		Reflect 1	**Plan 2**	**Reflect 2**	**Plan 3**	**Reflect 3**	**Plan 4**	**Reflect 4**	**Plan 5**	**Reflect 5**
Jenny	Craftsperson	2	2	2			2	1	2	
	Technician		1	1		1	3			2
	Basic Technician		2	1		1		1	2	
	TOTAL	2	5	4	0	2	5	2	4	2

I was an active participant in all meetings, initiating many reflective episodes. This was my project, and this is the likely reason I initiated and participated in so many reflective episodes. However, in the content area (EoEC) where I was not considered the expert, Luke took over the leadership role, planning and preparing activities for learners. This contrasts to meetings focussed on the light content, where I took over the leadership role. None of the other teachers came prepared with possible activities and ways to challenge alternative conceptions learners have. Comparing my reflective practice year on year, for the same content it was only in the plan meetings (year 1: year 2) where the was a slight increase in the number of reflective episodes that I participated in. I was able to reflect at the craftsperson level from the first meeting. The highest number reflective episodes that I participated in that was coded at the craftsperson level occurred in reflect 4.

6.5 Discussion

For two years, teachers attended PLC meetings that were focused on exploring ways to work with LPK for two content sections within Grade 8 Natural Sciences curriculum: EoEC and Light. Working collaboratively teachers planned lessons and designed activities providing opportunities to interact with LPK. PLC meetings took place that provided opportunities for teachers to reflect on their practice. Effective PLCs are dependent on teachers sharing similar experiences (Vescio et al., 2008). Having teachers plan lessons and activities for the same content, provided opportunities for teachers to reflect on what happened when the lesson was taught and then to reflect and rework lessons.

In discussing the results to answer my third research sub-question: what influence does attendance at successive PLC meetings focused on reflecting how teachers engage with LPK, have on teacher participation and their level of reflection, I will first consider how teacher participation in meetings changed (or did not) and then unpack how the level at of teachers practice changed (or didn't), over the two years.

6.5.1 Teacher Participation

Comparing teachers' participation in discussions in the first PLC meetings to those that took place at the end of the project, there was an increase in teacher participation. However, working within a PLC is complex. There was not a linear progression in teacher participation in reflective episodes from one meeting to the next. Many factors influenced teacher participation: first the content of meeting, second the type of meeting (plan vs reflect), third the content knowledge of the teacher and finally the leader of the meeting I will discuss how teacher participation was influenced by these factors.

6.5.1.1 Content of PLC Meeting

The diverse content (EoEC and light) provided different opportunities for teachers to reflect on how they interacted with LPK. EoEC by its nature provided more opportunities to engage with LPK, compared to the light content. Whilst the number of reflective episodes for each content area remained much the same year on year, teacher participation in reflective episodes increased from one year to the next. The two inexperienced teachers Adele and Kate, showed a greater increase in participation in year 2, compared to that of the two experienced teachers. In the first year of the project participation by the inexperienced teachers in reflective episodes was low for the content EoEC. Their participation in reflective episodes was even lower for the light content. In the second year both teachers had increased the number of reflective episodes they participated in for both content areas.

Teachers' participation in reflective episodes is complex and was affected not only by the content of the curriculum that was the focus of the PLC meeting but also the 'type' of PLC meeting: plan or reflect.

6.5.1.2 Type of Meeting: Plan vs Reflect

More reflective episodes were counted in plan meetings, compared to reflect meetings, for the same content area, i.e., comparing plan 2 with reflect 2. It may be that teachers were aware that following the plan meeting they would be required to teach a lesson that would be recorded as part of the project, so their interest in reflecting was enthused. This is supports findings reported by Chikamori et al. (2013) who stated that teachers in their lesson study project, were not as motivated in the final reflection meeting, knowing they were no longer required to teach. Teachers showed less interest compared to the meeting that took place just before teachers were required to teach.

6.5.1.3 Content Knowledge of the Teacher

Findings from my study showed that teachers with sound content knowledge were enthusiastic in PLC meetings, this being reflected in their high levels of participation in reflective episodes. They were quick to offer suggestions and critically reflect on what had happened. As such many reflective episodes were initiated by the teachers with sound content knowledge. This echoes the findings of Reed, Davis and Nyabanyaba's (2002) study, who reported that teachers with sound subject and pedagogic knowledge were able to reflect on their practices. However, their study did not report on changes in teachers' reflective practice with continued attendance at meetings, nor did it discuss teachers' reflective practice when the content of what is being reflected on changes.

With continued attendance at PLC meetings teachers' participation in reflective episodes increased, when comparing the type of meeting (plan vs reflect) and content, year on year. Where a teacher's content knowledge was poor, participation in reflective episodes was low compared to a teacher whose content knowledge was good. However, increases in participation in reflective episodes, year on year, was found for both teachers with poor and good content knowledge.

Due to the vast scope of content within the Natural Sciences curriculum, a teacher may have sound content knowledge within one topic and be lacking in another. It did not matter how much teachers knew about a topic at the start of the project, as teachers became familiar with the content and gained experience, having taught the content to many classes over a two-year period, the number of reflective episodes they participated in increased as the project continued. This may be explained in terms of Vygotsky's (1978) ZPD, where more skilled teachers supported novices in developing their pedagogic content knowledge and content knowledge. Whilst this was my project I was not considered the only expert, Luke too assisted in moving teachers through their ZPD, in what Kuusisaari (2014) refer to as symmetrical collaboration. Wilburn (2019) confirms the value of using 'expert' teachers as a pedagogic resource in assisting less confident teachers with their practices.

As teachers gained confidence on the unfamiliar content, as well as in experience, both their participation in reflective episodes and level of reflection improved. These findings contrast to those of Chikamori et al. (2013) who reported on a high level of participation from the research team in reflect meetings, following several cycles of a lesson study. They described input from teacher participants as poor. In my study, Luke was the experienced, subject expert with the content EoEC, he was not the researcher. However, in the 'light' content, I was both participant teacher and researcher and emerged as the leader. Without good leadership a PLC will not function effectively (Bolam et al., 2005). I turn my discussion to consider the role of the leader in a PLC meeting in encouraging participation.

6.5.1.4 The Leader

The success of PLC meetings was dependent on at least one person in the group taking the lead. Brodie (2013) stressed the important role facilitators in leading a PLC. Luke was the leader, for the content EoEC, his content knowledge was sound, and he had a wealth of pedagogic content knowledge. He guided the group through its initial meetings focused on EoEC. The group depended on him to bounce ideas off. I emerged as the leader with the 'light' content, being the only participant to explore research on common alternative conceptions learners bring to the class and to suggest activities to challenge these alternative conceptions. In my study, the two experienced teachers emerged as leaders, each for a different content area.

Where teachers step up and become leaders, Hollins et al. (2004) assert that it is likely that such PD will be sustainable and will continue after the intervention has been introduced.

Jones, Rua and Carter's (1998) study reported instances where experienced teachers supported inexperienced teachers and other instances where novice teachers supported their experienced peers. Teachers have varied understandings and skill sets based on their past experiences and formal education. It would be unrealistic to expect teachers to be experts in all content the Natural Sciences content areas. This is the reason novice teachers were able to support their experienced peers. Whilst the leadership role changed in my study, it did not move to the inexperienced teachers and stayed between the two experienced teachers even though I was not considered an expert in the content. Whilst the leadership role remained with the two experienced teachers, teachers spoke of how they were supported by others in the group in improving either their content or pedagogic knowledge or both. In this way teachers were assisting each other move through their ZPD.

Two aspects that were important in moving teachers through their ZPD, were first that a leader needed to guide the group through its reflections and planning and second teachers needed to feel safe such that they felt comfortable exposing perceived vulnerabilities. Walker (1994) reported that when teachers in her study felt respected and supported, they start reflecting.

Both experienced and inexperienced teachers in my study had expressed value of the trusted space that had been created that allowed them to take part in discussions and learn from others. As Brodie (2013) stated once established, a PLC provides a challenging and safe space for professional learning. I turn my discussion to consider how with continued attendance at PLC meetings, the level at which teachers reflected changed, if at all.

6.5.2 Level of Reflections

The level at which teachers reflected varied from teacher to teacher and meeting to meeting. There was a progression in the level at which teachers reflected when comparing the same content and type meeting, year on year. Not only did teachers interact and reflect more with the content EoEC compared to the light content, but the level at which they reflected was also higher for the EoEC.

Like O' Sullivan's Namibian teachers (2002), teachers in my project, on occasion, struggled to reflect at Zeichner and Liston's (1987) technician level. O' Sullivan's (2002) basic technician level of reflection was a useful level of reflection to use, as teachers were reflecting, albeit at a low level, and this level of reflection made it possible to code these reflections.

Namibian teachers in O' Sullivan's (2002) study, were different in some respects to teachers in my project as the Namibian teachers were trained in the apartheid years, and were either under-qualified or unqualified. All teachers participating in my study had attended well-resourced schools, and were professionally qualified, yet they struggled to reflect, particularly at the start of the project. A second difference between the Namibian teachers and teachers in my study was that the Namibian teachers only started to reflect at the end of their 3year study. In my study both experienced and inexperienced teachers reflected from the first meeting. Inexperienced teachers' initial reflections were often at low reflective levels. Yet instances of the inexperienced teachers reflecting at the craftsperson or technician level occurred in the first meeting.

Having developed their own scale to measure the level at which teachers reflect Chikamori et al. (2013) reported that teachers reflected at a higher level during the meeting that took place just before teachers were required to teach, compared to the reflection meeting that took place after the teaching had been completed. Results from my study are more complex, than those of Chikamori et al. (2013) as the lessons they planned involved one content area, whilst my research is concerned with two content areas. I will discuss results from each content area separately. For meetings based on EoEC (plan 2, reflect 2, plan 4 and reflect 4), in each successive meeting there was an increase in the number of reflections coded basic technician. More reflections were coded at the technician level in plan meetings, compared to reflect meetings. Reflections coded at the craftsperson level increased from plan 2, to reflect 2 with the greatest number of reflections coded 'craftsperson' in plan 4. Like Chikamori et al. (2013) there was a decline in the number of reflections coded at high levels (craftsperson) in the reflect meetings.

For the light content (plan 3, reflect 3, plan 5, reflect 5), from one year to the next, there was an increase in the number of reflections at the lower level: i.e., basic technician and technician, in all meetings except the last reflect meeting. The decrease in basic technician and technician level of reflection is likely because reflect 5 was the final meeting with teachers, and teachers were aware that their lessons would no longer be recorded. Interestingly the level at which teachers reflected from plan 3 compared to reflect 3, remained much the same for the two meetings in year 1. When comparing teachers reflective practice in the first meeting of the second year (plan 5) with reflect 3, not only did the number of reflective episodes increase but so too did the level at which teachers were reflecting, with almost triple the number of ‘craftsperson’ reflections occurring. However, the number of reflections coded at this high level dropped to its lowest in the last reflect meeting, reflect 5.

There was not a linear progression in the level at which teachers reflected from meeting to meeting, or within a meeting. In the same meeting a teacher could reflect at the craftsperson level and then not participate in some reflective episodes. The level at which teachers reflected was dependent on their content knowledge. Where teachers had sound content knowledge so the level at which they reflected was high. This supports findings by Reed et al. (2002). However, as stated previously (6.5.1.3) having sound content knowledge in one area in the Natural Sciences curriculum, does not mean that is true for all content areas. This then has a knock-on effect as to the level which a teacher can reflect on different topics. Luke, the subject expert on the EoEC content was reflecting at the craftsperson level in reflect 1, plan 2 and plan 3. However, during plan 3 (light), none of Luke’s reflection were at this level. Having taught the content, in the next meeting, reflect 3, Luke once again had instances where he reflected at the craftsperson level. For the remainder of the meetings, Luke reflected at this level. Further, more instances of Luke reflecting at the basic technician level, occurred during meetings focused on the light content compared to those concerned with the EoEC content.

6.6 Conclusion

In answering the third research question what influence does attendance at successive PLC meetings focused on reflecting how teachers engage with LPK have on teacher participation in the meeting, the broad answer would be that given numerous opportunities to reflect on their practice by attending several PLC meetings, teachers participation in PLC meetings increases as does the level at which teachers reflect. However, various factors play a role in teachers’ reflective practice. The sounder teachers’ content knowledge, the greater their participation in reflective episodes and the higher the level at which they reflect. Where teachers were confident with the content, they were able to initiate reflective episodes, and reflect at the craftsperson level. Where teachers were unsure of content, they reflected less and at a lower level. Teachers’ participation and level of reflection increased in ‘plan’ meetings that took place just before a lesson was taught. Reflecting on past lessons, decreased both participation in reflective episodes and the level of reflection.

Experienced teachers participated in more reflective episodes compared to inexperienced teachers. However, with time and continued attendance at PLC meetings, so inexperienced teachers’ participation in reflective episodes increased. By the end of the second year both inexperienced teachers were initiating reflective episodes. Not only were inexperienced teachers participating more but the level at which they were reflecting also showed gains. At the start of the project inexperienced teachers' reflections were mostly at the lower reflection levels, as teachers became familiar with the content by attending PLC meetings and teaching the content so the level at which they reflected increased.

PLC meetings were dependent on someone leading the meeting: Leaders not only share their expert knowledge; they create a space for teachers feel safe allowing them to reflect on their practices. The Natural Sciences curriculum has diverse topics, and it is unlikely that a teacher would be an expert in all content areas. In my study, the leader position changed with the topic. The teacher who was the recognised electrical expert took the lead in the EoEC content. I was the leader for the light content, as no other teacher felt confident to take over this position. As inexperienced teachers in my study gained confidence it is hoped that as new inexperienced teachers join the group, that the former teachers will become leaders. In this way expert teachers will mediate moving teachers through their ZPD, through symmetrical collaboration.

Working collaboratively in a PLC, over a two-year period resulted in gains in teacher's reflective practice. Teachers assisted each other move through their ZPD. It is hoped that having the leadership of the PLC dependent on the teachers and not an outsider, as well as by keeping the focus of the meeting context specific and ensuring a safe space to collaborate that this PD will be sustainable. Implications from these findings are the importance in identifying motivated leaders within schools to lead PLCs. These teachers need to be trained and supported, such that safe spaces are created allowing teachers to reflect on their practices in a trusted environment.

Chapter 7 Conclusion

7.1 Introduction

My study was concerned with exploring how teachers' interactions with learners changed as they reflected and planned activities to include what learners know about the topics 'effects of electric current' (EoEC) and 'light' into their lessons. The motivation for doing this was for teachers to define aspects of their teaching which need restructuring and then to come up with ways of addressing the deficiencies they had identified. Working within the interpretivist paradigm, I used an action research design to conduct my research, with 5 cycles being completed over two years. Within each cycle, the following phases occurred: act (classroom practice), observe (what happened in the classroom), reflect (on classroom practice in a PLC), and plan (rework activities for future lessons). During the 'act' and 'observe' phases I was concerned with the interactions that occurred between teachers and learners, as teachers provided opportunities for learners to make their LPK explicit. Reflect and plan meetings allowed teachers to work collaboratively considering what had happened during the lesson and rework lesson plans and activities in the hope of improving both activities and the interactions between teachers and learners. My study focused on unpacking the interactions that occurred between the teachers and learners in the classroom, and the teachers' reflective practice in the PLC meetings.

In answering my main research question: how do interactions concerned with exploring LPK change, as teachers participate in a PLC, focused on encouraging learners to make their knowledge explicit, I unpacked and coded teacher interactions with learners, learner responses and preferred teacher moves when teachers created opportunities to explore LPK. These aspects of teacher interactions were tracked over the two years. At the start of the project, teacher interactions were predominantly IRE, with teachers asking low order questions. Learners responded in single words or phrases, often as a chorus. When teachers included 'probes' or 'toss back' moves, interactions changed to IRPRE. Asking questions of a higher order, followed by probing questions or asking a classmate to explain their meaning further, resulted in learners responding in complete sentences, often giving reasons for what they said. Changes in the way teachers interacted with LPK can be attributed to teachers reflecting on their shared experiences and then seeking ways to improve their pedagogic practice. I was also interested in finding out how teachers' reflective practice changed with continued attendance at PLC meetings, as it was during these meetings where teachers decided how to better interact with LPK.

In this chapter, I provide a summary of my findings, by answering the three research sub-questions. I then explain these findings within sociocultural theory and describe methodological findings that emerged. I continue the chapter by being upfront about the limitations of this small study, considering the implications of my findings and making recommendations for both classroom practice and further research. I end the chapter with concluding comments that include my personal growth over this journey.

7.2 Summary of findings and how they answer my research questions.

To answer my main research question, how do interactions concerned with exploring learner prior knowledge change, as teachers participate in a PLC focused on encouraging learners to make their knowledge explicit, I asked three sub-questions.

Research sub-question1
In their baseline teaching practices, how do teachers interact with LPK?

Research sub-question 2
Why do teachers interact with LPK in the ways that they do?

Research sub-question 3
What influence does attendance at successive PLC meetings focused on reflecting how teachers engage with LPK, have on teacher participation and their level of reflection?

The first two research sub-questions were focused on teacher-learner interactions as learners made what they already know explicit. The first research sub-question was concerned with how teachers interacted with LPK at the start of the project. The second research sub-question considered changes in teacher-learner interactions over the two years data were collected and reasons for these changes are discussed.

Changes in how teachers interacted with learners, were a result of discussions that took place when teachers met as a PLC to reflect on what had happened during lessons and plan how to remedy that which was identified as a challenge. The third research sub-question was focused on how teachers reflected on their classroom practice, particularly that which involved working with LPK. When answering research sub-question 3 I was focused on unpacking how teachers' participation and level of reflection was influenced by regularly attending PLC meetings, where the focus was on exploring LPK. I continue to provide a summary of my findings in terms of the three research sub-questions and use these findings to answer my main research question.

7.2.1 Research sub-question 1: In their baseline teaching practices, how do teachers interact with LPK?

In their baseline lessons, all teachers provided opportunities to explore LPK. To unpack how teachers interact with LPK in their baseline lessons, I answered three questions: (a) when in their baseline lessons do teachers explore LPK? (b) What were the sources of LPK teachers drew on during baseline lessons and (c) What were the patterns of interaction teachers use when engaging with LPK, in their baseline lessons?

Teachers did not interact with LPK in their lessons at the same time. Where the teacher was an expert in the content being taught, interactions with LPK occurred throughout the lesson, whereas teachers whose expertise lay in other topics, interacted with LPK at the beginning of the lesson.

The second question I asked when answering unpacking teaching practices during baseline lessons was: what are the sources of LPK teachers draw on during their lessons? Teachers preferred source of LPK was that which came from formal instruction. All teachers provided opportunities for learners to make what they have learnt in a previous lesson explicit. This knowledge could have been gained in an NS lesson from earlier in the year, or when the same topic was taught in an earlier grade. However, teachers expressed frustration exploring this knowledge as often learners were unable to recall what had been previously taught. Even though research reports on the importance of challenging alternative conceptions learners may possess (Posner, Strike, Hewson, & Gertzog, 1982), no opportunities were provided to do this. Linking what learners already know to new concepts being taught is essential for meaningful learning (Scott, Mortimer, & Ametller, 2011). Where the knowledge learners have conflicts with what is being taught, the new knowledge won't be accommodated or assimilated into the existing knowledge, resulting in learning concepts in isolation from what is already known (Duit & Treagust, 2012).

Whilst knowledge gained from formal instruction was the preferred LPK to tap into, instances where teachers related what was being taught to learners' everyday experiences also occurred.

Two teachers created opportunities to interact with LPK whose source is from language to explore how learners understand a scientific term, that is also used in everyday English, for example, the word 'shock' was explored.

The third question I asked to help answer research sub-question 1 was: What are the patterns of interaction teachers use when engaging with LPK? In all four teachers' baseline lessons, teachers' preferred pattern of interaction was the triadic IRE, where teachers provided opportunities for learners to respond to a question, that was asked to interact with LPK. However, learner responses were evaluated as being correct or incorrect, no opportunities were given to explore learner meaning.

It is widely reported that teachers tend to ask learners low order questions, from Singapore (Chin, 2007), to Brazil and the UK (Mortimer & Scott, 2003). This was true for the teachers in my study. As a result, learners replied with single words, often as a chorus. Teachers would then evaluate the learner contributions, correct if the responses agreed with what they had planned and incorrect if their responses differed. Teachers spent little time exploring learner meaning when a response was given, that had been evaluated as being wrong. Instances were found where teachers used probes and 'toss back' moves to provide opportunities for learners to explain their meaning, particularly when responses were incomplete. All baseline lessons were considered interactive, in that the teachers provided many opportunities for learners to answer questions or complete activities. However, lessons were 'authoritative' as teachers were concerned with focussing on content that needed to be taught (Mortimer & Scott, 2003).

One of the purposes of the research was to provide teachers with opportunities to plan, act and reflect on the way they interact with LPK, in the hope of improving the meaning learners make of science concepts. Baseline practices allowed teachers to reflect on their classroom practices and consider how they interact with LPK at the start of the project. In the cycles that followed, teachers planned lessons that considered: various sources of LPK, possible alternative conceptions learners may have for topics taught, possible questions to ask learners as well as how to respond to learner contributions so that more of what learners know is revealed.

7.2.2 Research sub-question 2: Why do teachers interact with LPK in the ways that they do?

Social constructivism has as one of its tenets that meaningful learning occurs when new concepts to be learnt are anchored in what is already known. Using the tool of language those that are experts mediate learning. It is by asking questions that teachers provide a space for learners to make what they know explicit and can guide learners to link new concepts to those that they have already made sense of. However, unpacking and exploring LPK is complex. Baseline practices (cycle 1) revealed teachers' preferred pattern of interaction when exploring LPK was the triadic IRE. It was in the PLC meetings that teachers were made aware of this and through the course of the project, teachers deliberately planned to explore LPK by including IRPRE patterns of interaction. When teachers include more IRPRE patterns of interactions, learners are provided with opportunities to explain their meaning and more learners can have their voice heard. In this way, the communicative approach moves from being interactive authoritative to interactive dialogic. In understanding why teachers interact with LPK the way they do, I first considered how the patterns of interactions changed when teachers explored LPK, having reflected on and planned lessons to include opportunities to work with LPK.

Having planned to include more interactions with learners, not only did the number of interactions increase when comparing lessons from like topics from one year to the next so too did the number of IRPRE interactions. The topic 'Effects of Electric Current' (EoEC) was taught before the topic 'light'. There was no increase in the number of interactions that occurred in lessons as teachers moved from teaching EoEC to light. The reason for this is that learners come to class with more knowledge on electricity than light. Learners are familiar with appliances that use electricity from home and school, and electromagnets formed part of the primary school Technology curriculum. The knowledge grade 8 learners bring to the class regarding the topic light included being familiar with examples of some luminous objects, for example, the sun, a candle or light bulb, and that opaque objects cast shadows. As a result, more opportunities to interact with LPK occurred when teaching the topic EoEC than light.

A second factor that influenced the pattern of interaction teachers opted to use when exploring LPK, was the behaviour of learners. Where learners remained on task teachers interacted with learners, probing a learner to explain their meaning, or asking a peer to discuss their meaning with a toss back move. However, where learners went off task, teachers tended to either shut down any form of interaction, moving the lesson to a non-interactive authoritative communicative approach, or the pattern of interaction reverted to IRE, an interactive authoritative communicative approach. Opting for an authoritative communicative approach allowed the teacher to keep control of disruptive learners as well as keeping the lesson on its planned path.

Having considered how the patterns of interaction changed to including more IRPRE interactions, I then considered how are learner contributions influenced by the 'I' in the IRE or the 'I' and 'P' in IRPRE patterns of interaction? Without planning the types of questions to ask, teachers tended to ask learners low order questions. When teachers asked higher-order questions, followed by a prompt or 'toss back' move, learner responses changed to complete sentences, often including a reason for a statement made. In answering the second research sub-question Why do teachers interact with LPK in the ways that they do? My study found that initially, teachers did not plan higher order questions to ask learners, as a result, learners' responses were single words or chorus. When teachers planned to interact more deeply with LPK, not only did the questions teachers ask change, but teachers also prompted learners to explain their meaning or asked a classmate for their explanation to question.

The third aspect I considered when unpacking why do teachers interact with LPK the way they do, was to consider what moves teachers prefer to use when responding to a learner utterance. As the preferred pattern of interaction in baseline practices was the authoritative IRE, the most common teacher move coded was 'evaluate'. Teachers affirmed learner contributions that agreed with what science accepted as correct. Where learner responses were not what was planned for, teachers did not explore the alternative conception, rather the teacher would provide the 'correct' answer and the lesson continued. Whether a learner's response was deemed acceptable or not, teachers did not explore learner meaning. Having attended PLC meetings teachers were made aware of the high prevalence of IRE interactions and how little probing of learner meaning occurred during lessons. Once teachers became aware of the 'probe' and 'toss back' move so the incidence of these teachers' moves increased in lessons. However, this sometimes meant some learners became disinterested as the teacher explored learner meaning with a single learner. Where learners went off task, teachers either shut down the IRPRE chain and opted for IRE interactions, evaluating learner responses or, stop interactions with learners.

Whilst I have considered why teachers opted to use the pattern of interaction they did while exploring LPK, the fourth question I asked to answer my second research sub-question was; what factors influenced how teachers interacted with LPK? The single most important factor that influenced teacher how teachers interacted with LPK was participation in a PLC. If it were not for meeting regularly in a PLC to reflect and plan how better to explore LPK, it is unlikely that the changes I have reported on would have occurred.

The success of the PLC meetings was dependent on a teacher stepping up into a leadership role and guiding their peers, to consider knowledge learners might have for a topic, planning activities, and questions that allow learners to reveal this. The role of the leader in my study changed, with the teacher who was considered the content expert in the group taking on the role of leader for a given topic. Traits of the leader included being motivated to share what they know, having sound content and pedagogic knowledge. A prerequisite for teachers to be able to contribute their ideas in a meeting is that the meeting is focused on shared experiences (Brodie, 2013). This allows teachers to reflect on their own experiences. However, doing so may place the teacher in a vulnerable position, as they are opening up to what others may consider something the teacher should know (Durksen, Klassen, & Daniels, 2017). Thus, the importance of creating a safe space where everyone is respected is essential if teachers are to move through their ZPD. Leaders are the ones responsible for creating a safe space, by acknowledging teacher contributions and working with teachers from wherever they are starting from, in terms of content and pedagogic knowledge in each topic. Leaders need to be patient.

In the first year of study, it was the leader who drafted the first worksheets. Luke was the leader for the content EoEC and took the lead for the light content. During the PLC meetings, teachers discussed how to improve the activities. Whilst it can be argued that all teachers in my study have completed qualifications where they should be aware of how to locate possible alternative conceptions learners have on a topic, the reality is teachers are so loaded with teaching classes, administration, and co-curricular activities, that their focus in the classroom is on curriculum completion. The alternative conceptions teachers were aware of, were those they had come across from their experience. I was the only teacher who spent time finding alternative conceptions to the topics in academic literature. It must be highlighted that this was my project, I was motivated to do so. I also had access to academic literature through the university library. Even if teachers wanted to stay abreast of educational research and possible alternative conceptions learners hold onto, they do not have access to digital databases.

Having taught the content and gone through the activities with their learners in the first year, teachers used these experiences in the second year to reflect on how to make improvements for lessons in the second year. Findings from my research showed gains in teachers' content knowledge from one year to the next. Changes in the way teachers interacted with LPK in the second year are likely to be attributed to discussions in PLC meetings. It was in these meetings teachers were made aware of alternative conceptions learners hold on to, discussed their frustrations of 'missing' or 'forgotten' LPK, as well as managing disruptive learners.

During PLC meetings teachers reflected on how they interacted with LPK and designed activities to challenge known alternative conceptions. They planned questions that allowed learners to make what they knew before new content was taught explicitly. In answering the second research sub-question: why did teachers interact with LPK the way they did? It was attendance and participation in discussions at PLC meetings that motivated teachers to put into action, what had been reflected on and planned for. If it had not been for the PLC it is unlikely that teachers would have changed the way, they interacted with LPK. This leads me to consider how teachers' participation and level of reflection changed as teachers attended PLC meetings.

7.2.3 Research sub-question 3: What influence does attending successive PLC meetings focused on reflecting how teachers engage with LPK, have on teacher participation and their level of reflection?

Due to the Practical Action research design, PLC meetings were categorised as being either 'reflect' or 'plan' meetings. Once teachers had taught the lessons on each topic, a 'reflect' meeting was scheduled. Reflect meetings were focused on teachers reflecting on their shared experiences. Having reflected on what had happened in the classroom, a 'plan' PLC meeting was arranged where using what had been discussed in the reflect meeting; activities, notes, and lesson plans were revised. As discussions in PLC meetings influenced the way teachers interacted with LPK in the classroom, I investigated how teacher participation and their level of reflection changed as teachers attended more meetings.

When comparing teacher participation in the first PLC meeting with what happened in the last PLC meeting, an increase in teacher participation occurred. However, this increase was not linear and was influenced by various factors, the topic of the meeting, the type of meeting, and the content knowledge of the teacher. Some topics by their nature provided more opportunities for teachers to interact with LPK. For instance, learners come to class with more knowledge in the topic EoEC vs light, because of this more opportunities were created for discussions in meetings focussed on EoEC compared to those focussed on the light content. Even though teachers had shared experiences when reflecting on the same content taught and activities completed, teacher participation in plan meetings was more than in reflect meetings. Chikamori, Ono, and Rogan (2013) had reported similar findings in their research focussed on using lesson study. Perhaps a reason for this is that teachers are aware that following the 'plan' meeting they will be required to teach and need to be certain what and how they would teach. This was not the case for the 'reflect' meetings, consequently, teacher participation in 'reflect' meetings was lower compared to 'plan' meetings.

Teachers with better content knowledge and pedagogic knowledge were the ones who participated more in discussions. As teachers' content knowledge improved, so participation in meetings increased. It is unlikely that teachers are experts in all topics in the NS curriculum since it includes diverse subject areas, viz biology, physics, chemistry, and astronomy, therefore teacher participation may vary from one topic to another. However, findings from my study showed, that even when teachers' participation in discussions was initially low in a topic, by attending many meetings focussed on the same topic teacher participation increased. Expert teachers in a topic were the ones in my study who led the PLC meetings, guiding and assisting teachers from where they were, to what needed to be taught. When expert teachers assist less confident teachers, they are used as a pedagogic resource. (Wilburn, 2019). Further, when teachers are the person who led PLC meetings, and not outside facilitators it is likely that the PD will be sustainable (Hollins, McIntyre, DeBose, Hollins, & Towner, 2004).

Not only did teacher participation in PLC meetings increase over the two years of the study so too did the level at which teachers were reflecting. Initially, teachers struggled to reflect. Those that participated in early meetings, tended to reflect at a low 'basic technician' level, where they were able to recognize a problem but were unable to suggest a solution. As teachers attended more meetings, the level at which they were reflecting started to increase, with inexperienced teachers reflecting at the high 'craftsperson' level. Reflections at the 'craftsperson' level are ones that are focussed on not only identifying the problem and its solution but also consider why the difficulty occurred. The last PLC meeting was characterized by not only a decline in teacher participation but also a decline in the level at which teachers were reflecting. This may be because it was the end of the research project and teachers were aware that their teaching no longer formed part of the research, or it could be that it was the end of the term and teachers were tired having been under pressure to complete both teaching and administrative duties before term-end.

7.3 Theoretical findings

The purpose of my research was for teachers to collaborate in a PLC focusing on providing opportunities for learners to make what they know explicit. Vygotsky's sociocultural theory was the theoretical framework that guided the research. This theory asserts that meaningful learning occurs when teachers consider the new 'science concepts' to be learnt and link these to what the learner already knows. Learning is mediated by using the tools of talk. At the start of the project teachers' interactions with LPK were authoritative, the teacher asked a question, and the response was evaluated as being correct or not. No exploration of deeper learner meaning occurred. Whilst teachers interacted with learners, their focus was on teaching the new content. Teachers knew what the end goal of their lesson was and using the tools of language got there. However, whether learners were supported from what they could do on their own to where they needed to be, could be questioned. The focus of the lesson was on the teacher explaining new content, asking questions as the lesson proceeded. Teachers did not deviate from what they had planned. The questions teachers asked were of such a low order learner responses were single words or phrases, not giving the teacher much insight into what the learner knows. Where learners replied with an unexpected reply, these were corrected and not explored further.

When teachers reflected on how they interacted with LPK, the patterns of interaction changed, with teachers exploring what learners know more deeply. Teachers included more learners in discussions, allowing learning to occur on the interpsychological plane. As learners were allowed to explain their meaning, so teachers could move learners through their ZPD. The teacher acted as the mediator, blending the new concepts to be taught with what learners already knew. Mortimer and Scott (2003) assert that it is when teachers allow learners to talk about what they already know, opportunities are created for teachers to guide learners to understand new concepts in a meaningful way.

Similarly, sociocultural theory is a useful theoretical lens to explain the changes in the way teachers interacted with learners and the gains in teachers' reflective practice that occurred, over the two years of the project. PLC meetings were safe spaces where teachers reflected on similar experiences. Contributions teachers made, in PLC meetings were respected. Initially, participation by inexperienced teachers and the level at which they reflected was low. With continued attendance, and experience both their participation and level at which they reflected increased, as they moved through their ZPD, being guided by the 'expert' teacher. Experienced teachers too showed gains in participation and the level at which they reflected comparing the first meetings to those in the second year. Unlike the learners, for teachers there was no 'science content' to be learnt, rather gains in their reflective practice occurred. If it had not been for the meetings, interacting with each other on the interpsychological plane, it is doubtful that there would have been changes in teachers' reflective practice.

Teachers found working as a PLC worthwhile. Findings from this research agree with Brodie's (2013) characteristics of a successful PLC: first the learning needs to come from teachers shared experiences and be related to the school context. Sharing similar experiences allowed teachers in my study to feel comfortable discussing what had happened in their classrooms. Teachers were able to identify with similar experiences, making conversations robust. Second, teachers need to reflect on both learner understanding and their teaching. Opportunities to discuss challenges were provided. Much time was spent in PLC meetings, discussing how to change activities, predict and plan for learner responses. Third, successful PLCs have support of leaders: both the GDE and principal of the school had given permission for the study. Finally, Brodie states that successful PLCSs are dependent on the facilitator. This was certainly true of my study. Whilst the role of the leader changed, based on the topic being taught, the role of the leader was important. It was the leader that created a safe trusted environment, where teachers were able to grow and learn together.

7.4 Methodological Findings

When deciding on the research design to use for this project, I wanted teachers to be involved in finding ways to explore LPK. I sought to avoid a top-down approach of coming with a ready-made intervention, to be used during data collection only to be abandoned once the last lesson was recorded. I found using practical action research, an effective research design, to use for professional development. It was by reflecting on shared experiences that teachers were able to suggest how to improve that which did not work and then try out what had been discussed in lessons that followed 'plan' meetings. Initially teachers' participation in meetings was low. Having few teachers participate in discussions was a challenge. However, as the project continued and teachers attended more reflect and plan meetings, so their participation and reflective practice increased.

When a PLC is organized using an action research design, to solve context specific challenges, professional learning results. Issues and concerns raised by teachers are understood by colleagues as the context they are working in is the same. It is likely that teachers will implement new strategies discussed in plan meetings. Should the teacher encounter challenges whilst implementing the intervention, these can be brought up for discussion and debate at the reflect meeting and ways of improving the intervention can be planned for, rather than abandoning the intervention as sometimes happens with once off PD. Teachers in my study reported on gains in both their content and pedagogic knowledge and they hoped that the PLC would continue beyond the project. Action research results in sustained school-based support for teacher interventions.

The success of using an action research design was due to teachers sharing the same context, teachers participating in all phases of a cycle (act, observe, reflect and plan), and cycles, and one of the teachers taking the lead. The leader was the person who initially suggested activities, initiated discussions and created a safe space for teachers to collaborate. Had it not been for one of the teachers stepping up into the 'leader' role the success of the PLC and the research design is questioned. Findings from my research support the use of action research as a format that could be used to structure successful PLCs, resulting in professional learning.

7.5 Limitations of the study

I turn now to consider some of the limitations of my study reporting on the changes in how teachers interacted with LPK having participated in PLC meetings. The first limitation is that my sample size is small: four teachers. Caution should be taken in extending these findings beyond this sample. The second limitation is that all four teachers taught at the same well-resourced sub-urban high school. Whilst the school in my study is a government (public) school, the context is distinct from most high schools in South Africa located in townships or rural areas. The school where the research was conducted was built and resourced under the apartheid government with to educate white children, referred to as a Model C school. The infrastructure is better than many township and rural schools, it possesses a functional library and five well-stocked laboratories. From school fees collected, the school governing body employs additional teachers to reduce the number of learners in classes. Further, most learners come from homes where at least one parent is employed. Whether these findings can be transferred to schools in South Africa in different contexts is questioned. Teaching under different conditions is likely to change what teachers opt to do in their classrooms. Identifying teachers who could lead PLCs in contexts different from the one I have reported on would allow teachers to find solutions to their unique context if PLCs used practical action research to both identify problems and find solutions to those problems.

The lens I used to analyze my data was informed by Mortimer and Scott's framework to analyze meaning making science classrooms particularly looking at the change IRE interactions. Data were coded to track changes in these interactions as they moved to include more IRPRE interactions. Other ways of interpreting data that were collected has not been explored. For instance, no consideration was given to analyzing the arguments learners and teachers using for instance Toulmin's argument pattern (Eccles & Wigfield, 2020), nor were reasons why teachers chose to do what they did explored using expectancy value theory (Eccles & Wigfield, 2020).

Finally, the scope of the project only allowed teachers to explore two topics in the NS curriculum, both occurring in the Energy and Change Strand. Three of the four teachers' expertise lay in the Life and Living strand. Whether teachers would be more aware of alternative conceptions learners may have and the knowledge learners bring to class when teaching topics where they are more confident, was not investigated. The reality in South African NS classes is that teachers are expected to teach topics where they are not specialists and are less confident, because of the diverse topics found in the curriculum.

Having outlined the limitations of my study I now consider the implications from my findings for officials from the Department of Basic Education to consider and make recommendations for further research.

7.6 Implications and recommendations for future research

From the beginning of my project, I was motivated for teachers in my study to find ways to better interact with LPK. I was not interested in coming with an intervention. Too many times teachers are sent to some form of PD where solutions are presented as ways to improve teaching and or learning. Trying to move teachers to where they should be without considering where they are at, is likely to result in teachers abandoning the new intervention, as teachers in Walton's (2014) study lamented and Buma (2018) reported.

Working within a PLC reflecting on shared experiences to rework how better to interact with LPK was essential in changing the way teachers explore the knowledge learners bring with them to class. Whilst teachers are encouraged to form and join PLCs, my experience has been that teachers are unsure what they should be doing in the PLC and as a result find little value in attending meetings. When the PLC has a purpose that allows teachers to share similar experiences, then teachers are likely to find value in attending meetings, start participating, and perhaps even changing what they do in the classroom. How and why to set up PLCs should be explained to teachers. Guiding teachers on how to use action research to solve their challenges may assist in forming functional PLCs. It is likely that forming PLCs within schools, where the context of teachers is similar will be a good start to setting up functional PLCs.

Whether results from my study are transferable to other school contexts within South Africa is questioned. Schools in South Africa vary from the well-resourced sub-urban schools, to those occurring in the township or rural areas. Research in these differing contexts is needed. Further, teachers in my study had some form of 'science' background and were familiar with identifying and solving problems. Research reporting on the effectiveness of using action research by non-science teachers in South Africa would be interesting.

Functional PLCs are not only dependent on teachers sharing a similar context and similar experiences, but the role of the leader is also crucial. Whilst it may be necessary for an outside facilitator to initiate the formation of a PLC, handing over the leadership role to a teacher is likely to result in the PLC sustaining itself once the outside facilitator leaves. The role of the leader is essential in ensuring teachers find value in reflecting on shared experiences in a safe space. Identifying and training teachers to lead functional PLCs within schools, is likely to go some way in changing teacher practices. Using expert teachers as a pedagogic resource should not be overlooked. NS is a subject with many diverse topics, expecting teachers to be experts in all topics is unreasonable. Findings from my study highlight the importance of identifying and training leaders within schools to lead PLCs.

Findings from my study showed that teachers merely scratch the surface when they interact with what learners know. Perhaps this is the reason school science remains isolated from everyday science as teachers fail to provide opportunities for learners to link what they already know to what is new. Teachers tended to ask low-order questions, seeking the correct answer. If teachers are provided with opportunities to reflect with their peers on the type of interactions occurring in their class, they may be surprised as to what they are doing, as opposed to what they think they are doing.

Further, alternative conceptions learners may have that education research has uncovered and published is not readily available to teachers. Teachers do not have access to the electronic databases of tertiary institutes and even if they did, would teachers take time to read lengthy academic articles? Whilst websites may be found listing some alternative conceptions learners may hold onto, for example, astronomy and electricity alternative conceptions https://www.astronomy.org/astronomy/misconceptions.html, and https://www.furryelephant.com/content/electricity/teaching-learning/misconceptions/ respectively locating these is something teachers in my study did not do. Perhaps a document with links to these websites available on either the Department of Basic Education website or Thutong (National education portal) informing teachers about them would make it easier for teachers to locate these.

Disruptive learners played a role in teachers choosing to shut down interactions and revert to a non-interactive authoritative approach as this was the easiest way to return order in the classroom. Working within the PLC teachers could develop strategies to manage learners when they go off task.

My study was concerned with exploring teacher-learner interactions that provide opportunities for learners to make their LPK explicit. I did not unpack discussions that occurred between learners while they completed group work activities. Some activities were designed to challenge alternative conceptions, or work with LPK from various sources. Exploring learner-learner interactions may reveal the types of interactions occurring between learners and if a learner emerged in the group that guided their peers through their ZPD.

What also interested me as the project continued was the role alternative conceptions play in understanding how learners make sense of a concept. When learners respond with an ‘incorrect response’ this is often seen in the negative, teachers evaluate the response as being ‘wrong’, leaving the learner feeling inadequate. However, these responses may be more useful than the ‘correct’ response. When a learner gives a ‘correct’ response it is assumed that the learner understands the concept being asked about and is often not interrogated further. When learners give alternative conceptions, opportunities arise for teachers to explore the learner’s understanding. From my experience, when learners respond, they are hoping that their answer is ‘correct’ and disappointed when it is not. Research with teachers where discovering and unpacking alternative conceptions that learners have is seen as a valuable pedagogic tool to inform lessons, would be interesting.

7.7 Concluding comments

At the start of my research, I was motivated to do research focused on improving learner understanding of science concepts by relating new concepts to be taught with LPK. Grade 8 learners come to the science class knowing something from past experiences, be they from previous lessons in the classroom or experiences outside school. This knowledge matters and is the foundation upon which learners will make sense of new concepts. Sometimes what is to be learnt agrees with what is already known, making learning easy and straight forward, in other instances what the teacher assumes is known may be forgotten, missing or the learner has an alternative conception. If teachers try to add new concepts to shaky foundations, it is likely that a deep understanding of new concepts will not occur. Learners are unable to link their everyday knowledge with what is being taught. When this happens, what is learnt in the science classroom, becomes isolated concepts, only useful in the science classroom and assessments. A deep meaning of science concepts is dependent on starting from what the learner already knows.

In my study teachers sought to find ways of better interacting with this knowledge. The interactive authoritative communicative approach was preferred by all teachers in their baseline practices. Teachers interacted with learners, by asking low order questions and evaluating learner responses. Opportunities for learners to challenge possible alternative conceptions were not given. Teachers were focused on moving through the lesson they had been planned. By working collaboratively over 2 years, teachers started changing their patterns of interaction from predominantly IRE to including IRPRE interactions, where teachers used 'probes' and 'toss backs' to elicit deeper meaning. Exploring learner understanding more deeply provided an opportunity for learners' voices to be heard, and teachers started to include an interactive dialogic communicative approach in the lessons. However, when learners went off task and or became disruptive, to retain control of the class teachers either reverted to the interactive authoritative communicative approach with IRE patterns of interactions, or all interactions were shut down. When the teacher opted to continue the lesson, with no input from learners, the non-interactive authoritative communicative approach was coded. Changes in the way teachers interacted with LPK were most likely due to the participation, reflection, and planning that happened in the PLC meetings.

If teachers are to change what they do in the class, PD should consider what teachers already know. Providing teachers with interventions and solutions to improve how they teach has been shown to be unsustainable as teachers try out something new and revert to their old ways of teaching. It was by working in a PLC where meetings were guided by an 'expert' peer, that a space where teachers were respected and were able to reflect on shared experiences was created. Teachers learnt from each other and changed their practices in their classes.

As I write this final paragraph and reflect on my journey over the past seven years, I have grown both as a researcher and teacher. As a researcher, I have learnt how to make sense of some aspects of what and why teachers do what they do and how to change that which is not working. Four years after collecting the data, I reflect on what I continue to do in my classroom: first, learners do know something about new scientific concepts to be taught and this should be explored. Second, what opportunities can I provide to make this knowledge explicit? Third, what are the interactions I allow in my class? The questions I ask sets up the type of response learners give. Finally, I have learnt to listen, really listen to learner responses. Where learners provide alternative conceptions, these are opportunities to understand why learners struggle to make meaning of science concepts. This research mattered as I sought ways to do as my father advised: 'educate, not teach' allowing my learners to make deep sense of what they were learning and to relate this to the world they know.

Chapter 8 References

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Appendices

Appendix 1 Letters to teachers inviting participation in project.

marang
WITS CENTRE FOR MATHS + SCIENCE EDUCATION

Protocol Number: 2015ECE007D

11 June 2015

Dear Miss [redacted]
I am a PhD student in the School of Education at the University of the Witwatersrand. I am doing research on exploring the use of different communicative approaches to integrate learner prior knowledge into the teaching and learning of science concepts in Grade 8.

My research involves working with Grade 8 Natural Sciences teachers to develop lessons that integrate learner prior knowledge into the teaching and learning of science concepts. I am inviting you to participate in my research. Should you agree to participate you will form part of a team which includes myself and the other Natural Sciences teachers from [redacted] High School that have agreed to participate. The reason why I have chosen [redacted] High School to do the research is because I would like my teaching to form part of the research. My Grade 8 Natural Sciences lessons will therefore also form part of the research. The research will take 6 weeks in the third term. Participation in the research is completely voluntary and you are free to withdraw from the research project at any stage, without giving reasons. You will not be disadvantaged in anyway should you decide not to participate.

Should you agree to participate, your name and identity will be kept confidential at all times and in all academic writing about the study. I will make use of pseudonyms when referring to the school, teachers and learners when reporting on my research. Your individual privacy will be maintained in all published and written data resulting from the study. Teachers who do not want to participate will not be prejudiced against.

The research project involves two individual interviews with teachers: one at the start and one at the end of the research project. It also includes two workshops, one that will take place at the beginning of the research on group work and the second one a week or so into the research on various communicative approaches that can be used in a class.

If you choose to participate, lessons with one of your Grade 8 Natural Sciences classes will be video recorded. We will then meet as a group of participating teachers and reflect on our lessons, using recordings as needed. We may need to rework lesson plans, to improve the integration of learner prior knowledge into the learning of science concepts. Lessons will be taught according to the revised lesson plan. These lessons will be video recorded. Where learners are placed in small groups, each group will be video recorded as well. Learners who do not want to participate in the study will be placed in the same group/s, and will not be video recorded. In whole class teaching situations non-participating learners will be placed outside the video frame and will not be recorded.

Following the lesson you will need to complete a questionnaire that considers the successes and weaknesses of the lesson. Once all participating teachers have taught the lesson we will meet as a group to reflect on its successes and weakness. Lesson plans may need to be revised. Participating teachers will then teach according to the revised lesson plan, this lesson will be video recorded. Immediately after the lesson you will be required to complete a second questionnaire. As done previously, once all participating teachers have taught their lessons, we will reflect on the revised lesson plan. Together we will then revise the lesson plan. Lessons and interviews are to be video recorded to ensure that all events are in the class room are transcribed: including nonverbal parts, for example a learner or teacher making gestures when asking or answering a question. I am interested in finding out how you experience integrating learner prior knowledge into lessons. I certainly do not have any correct answers to this investigation. Your input into this project will be valued and treated confidentially at all times.

I hope that by participating in my research you are able to find the workshops and reflections on lessons useful in your own teaching practices even once the research is complete.

Findings from the research will be used: to complete my thesis; write journal articles, make recommendations regarding policy and be presented at conferences. All research data will be destroyed between 3-5 years after completion of the project.

You will not be advantaged or disadvantaged in any way should you decide to participate or not participate. Your participation is voluntary, so you can withdraw your permission at any time during this project without any penalty. There are no foreseeable risks in participating and you will not be paid for this study.

Please let me know if you require any further information.
Thank you very much for your help.

Yours sincerely,

Jenny Woolway Supervisors: Dr A Msimanga 011 717 3073 Prof A Lelliott 011 717 3260

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0827760811

Teacher's Consent Form

Please fill in and return the reply slip below indicating your willingness to be a participant in my voluntary research project called: Exploring the use of different communicative approaches to integrate learner prior knowledge into the teaching and learning of science concepts in Grade 8.

I, ________________________ give my consent for the following:

	Circle one
Permission to observe you in class	
I agree to be observed in class.	YES/NO
Permission to be interview	
I would like to be interviewed for this study.	YES/NO
I know that I can stop the interview at any time and don't have to answer all the questions asked.	YES/NO
Permission for questionnaire	
I agree to fill in a question and answer sheet for this study.	YES/NO
Permission to be videotaped	
I agree to be videotaped in class.	YES/NO
I know that the videotapes will be used for this project only.	YES/NO

Informed Consent

I understand that:

- My name and information will be kept confidential and safe and that my name and the name of my school will not be revealed.
- I do not have to answer every question and can withdraw from the study at any time.
- I can ask not to be videotaped.
- All the data collected during this study will be destroyed within 5 years after completion of my project.
- I will not be prejudiced against in anyway should I decide not to participate in the study.

Sign______________________________ Date____________________________

Teacher Informed Consent Form for Permission to be videotaped.

I ____ do/ do not (circle one) give consent for me to be videotaped during Natural Sciences lessons and interviews associated with the research project: Exploring the use of different communicative approaches to integrate learner prior knowledge into the teaching and learning of science concepts in Grade 8.

Your involvement in the research project is voluntary and you are free to withdraw from the study at any time without any penalty or prejudice. Any sharing or publication of the research results will make use of pseudonyms, ensuring your anonymity. Recordings will allow me to identify themes that are common in all participating teachers' lessons and experiences. The recordings will be kept confidential and destroyed after 5 years.

____________________	____________________	____________________
(Print) Teacher Name	Teacher's signature	Date

Appendix 2 Letter to learner inviting participation in project.

marang
WITS CENTRE FOR MATHS + SCIENCE EDUCATION

Protocol Number: 2015ECE007D

14 April 2016

Dear Learner

My name is Mrs Woolway and I am a PhD student in the School of Education at the University of the Witwatersrand. I am doing research on: exploring the use of different communicative approaches to integrate learner prior knowledge into the teaching and learning of science concepts in Grade 8.

My research involves working with your Natural Sciences teacher and your classmates looking at how to include what you already know in science lessons. This research will involve some of your NS lessons being video recorded. If you are placed in small groups to work on activities I would like to video record your group's discussions as well.

I was wondering whether you would mind if I included you as part of my research. This is not compulsory at all, I am inviting you to participate in my research. I have chosen your class because your NS teacher has decided he/she would like to participate in my research. The research will last for 6 weeks in the third term. You do not need to participate in my research if you do not want to. This will not affect your marks in any way at all. You will not be in trouble if you decide not to participate. You will be treated the same if decide to participate or not to.

I will need your help with answering a questionnaire about your background and the languages you are able to speak. I also need to ask if you would mind me videotaping your teacher teaching the whole class and videotaping group work discussions. If you do not want to be video recorded you can choose to sit outside the video frame when your teacher is busy teaching the whole class, so you won't be recorded. Also, if you do not to participate in the study, when doing group work I will put you in a group with learners who do not want to be video recorded, and that group (s) won't be video recorded.

Remember, this is not a test, it is not for marks and it is voluntary, which means that you don't have to do it. If you do decide to participate I am not marking what you say or write as being right or wrong. There are no right or wrong answers. I am interested in finding out what happens in the class and what is said and written. If you decide halfway through that you prefer to stop, this is completely your choice and will not affect you negatively in any way.

I will not be using your name when I write up my report. I will make a name up for you so no one can identify you. I will also make up a name for the school and for your teacher. All information about you will be kept confidential in all my writing about the study. All collected information will be stored safely and destroyed between 3-5 years after I have completed my project.

Your parents have also been given an information sheet and consent form, but at the end of the day it is your decision to join us in the study.

I look forward to working with you!

Please feel free to contact me if you have any questions.

Thank you

Mrs J Woolway	Supervisors:	Dr A Msimanga	Prof A Lelliott
		011 717 3073	011 717 3260

P.O. Box 167427
Brackendowns
1454
ijkl@mweb.co.za
0118681056

Learner Consent Form

Please fill in the reply slip below if you agree to participate in my study called:

Exploring the use of different communicative approaches to integrate learner prior knowledge into the teaching and learning of science concepts in Grade 8

My name is: ________________________

Circle one

Permission to observe you in class
I agree to be observed in class. YES/NO

Permission for questionnaire
I agree to fill in a question and answer sheet for this study. YES/NO

Permission to be videotaped
I agree to be videotaped in class. YES/NO
I know that the videotapes will be used for this project only. YES/NO

Informed Consent
I understand that:

- My name and information will be kept confidential and safe and that my name and the name of my school will not be revealed.
- I do not have to answer every question and can withdraw from the study at any time.
- I can ask not to be videotaped.
- All the data collected during this study will be destroyed within 3-5 years after completion of my project.
- If I choose not to participate I will not be treated differently.

Sign______________________________ Date____________________________

Learner Informed Consent Form for Permission to be videotaped.

I ____ do/ do not (circle one) give consent for me to be videotaped during Natural Sciences lessons associated with the research project: Exploring the use of different communicative approaches to integrate learner prior knowledge into the teaching and learning of science concepts in Grade 8.

Your involvement in the research project is voluntary and you are free to withdraw from the study at any time without any penalty or prejudice. Any sharing or publication of the research results will make use of pseudonyms, ensuring your anonymity. Recordings will allow me to determine if there are themes common to other Natural Sciences classes where the same lesson is taught. The recordings will be kept confidential and destroyed after 5 years.

________________________ ___________________________ ______________________

(Print) Learner Name Learner's signature Date

Appendix 3 Letter to parent inviting participation in project.

marang
WITS CENTRE FOR MATHS + SCIENCE EDUCATION

Protocol Number: 2015ECE007D

14 April 2016

Dear Parent

My name is Jenny Woolway and I am a PhD student in the School of Education at the University of the Witwatersrand. I am doing research on exploring the use of different communicative approaches to integrate learner prior knowledge into the teaching and learning of science concepts in Grade 8.

My research involves working with Grade 8 Natural Sciences teachers at [redacted] High School. I am interested in finding out how teachers include the knowledge your child brings to the class in their lessons. Working with teachers we will develop lessons which will provide opportunities for learners to not only make their knowledge explicit, but to include these ideas into the teaching of new science concepts. It is hoped this will improve both teaching and learning allowing learners to work through activities with an understanding of science concepts. I will be present when lessons are taught. Lessons which form part of the research project will be videotaped. When learners complete activities in groups, the group's discussions will also be video recorded. The video recordings will not only be useful when teachers reflect on their lesson, they will also allow me to analyze class events in depth at a later stage, including those parts of the lesson where little talking takes place. I will conduct my research during the third term, lasting 6 weeks.

The reason why I have chosen your child's class is because they are taught by a Natural Sciences teacher who has agreed to be part of the research.

I was wondering whether you would mind if your child forms part my research. This is an invitation to participate and is certainly not compulsory. Your child will be asked to complete a questionnaire where I gather background information on your child for example age, gender, language spoken at home, language spoken at break, language spoken when going out with friends on the weekend. I will also be video recording whole class teaching and small group discussions.

Your child will not be advantaged or disadvantaged in any way if they choose to participate or not to participate. S/he will be reassured that s/he can withdraw her/his permission at any time during this project without any penalty. There are no foreseeable risks in participating and your child will not be paid for this study. Children not participating in the research will be placed in the same group/s and they will not be video recorded. Non-participating children will be placed outside the video frame in whole class teaching situations.

The school's name, all teacher names and your child's name and identity will be kept confidential at all times and in all academic writing about the study. His/her individual privacy will be maintained in all published and written data resulting from the study. Results from this research project will be: used to complete my thesis, write journal articles; make recommendations regarding policy and used in conference presentations.

All research data will be destroyed between 3-5 years after completion of the project.

Please let me know if you require any further information.

Thank you very much for your help.

Yours sincerely,

Mrs Jenny Woolway	Supervisors:	Dr A Msimanga	Prof A Lelliott
P.O. Box 167427		011 717 3073	011 717 3260
Brackendowns			
1454			
ijkl@mweb.co.za			
011 868-1056			

Parent's Consent Form

Please fill in and return the reply slip below indicating your willingness to allow your child to participate in the research project called:

Exploring the use of communicative approaches to integrate learner prior knowledge into the teaching and learning of science concepts in Grade 8

I, ________________________ the parent of ______________________

	Circle one
Permission to observe my child in class	
I agree that my child may be observed in class.	YES/NO
Permission for questionnaire	
I agree that my child may fill in a question and answer sheet for this study.	YES/NO
Permission to be videotaped	
I agree my child may be videotaped in class.	YES/NO
I know that the videotapes will be used for this project only.	YES/NO

Informed Consent

I understand that:

- My child's name and information will be kept confidential and safe and that my child's name and the name of the school will not be revealed.
- My child does not have to answer every question and can withdraw from the study at any time.
- My child can ask not to be videotaped.
- All the data collected during this study will be destroyed within 3-5 years after completion of my project.

Sign_____________________________ Date___________________________

Parent Informed Consent Form for Video Recording

.

I do/do not (circle one) give consent for my child ________________________ (name of child)
to be video recorded during Natural Sciences lessons associated with the research project: Exploring the use of different communicative approaches to integrate learner prior knowledge into the teaching and learning of science concepts in Grade 8.

Your child's involvement in the research project is voluntary and s/he is free to withdraw from the study at any time without any penalty or prejudice. Any sharing or publication of the research results will make use of pseudonyms, ensuring your child's anonymity. Recordings will allow me to determine if there are themes common to other Natural Sciences classes where the same lesson is taught. The recordings will be kept confidential and destroyed after 5 years.

________________________ ____________________ _____________
(Print) Parent's name Parent's signature Date

Appendix 4 Ethics clearance from the University of the Witwatersrand

Wits School of Education

27 St Andrews Road, Parktown, Johannesburg, 2193 Private Bag 3, Wits 2050, South Africa. Tel: +27 11 717-3064 Fax: +27 11 717-3100 E-mail: enquiries@educ.wits.ac.za Website: www.wits.ac.za

09 June 2015

Student Number: 8607147V

Protocol Number: 2015ECE007D

Dear Jennifer Woolway

Application for Ethics Clearance: Doctor of Philosophy

Thank you very much for your ethics application. The Ethics Committee in Education of the Faculty of Humanities, acting on behalf of the Senate, has considered your application for ethics clearance for your proposal entitled:

Exploring the use of different communicative approaches to integrate learner prior knowledge into the teaching and learning of science concepts in Grade 8.

The committee recently met and I am pleased to inform you that clearance was granted.

Please use the above protocol number in all correspondence to the relevant research parties (schools, parents, learners etc.) and include it in your research report or project on the title page.

The Protocol Number above should be submitted to the Graduate Studies in Education Committee upon submission of your final research report.

All the best with your research project.

Yours sincerely,

MMabeta

Wits School of Education

011 717-3416

cc Supervisor - Dr A Msimanga and Prof A Lelliott

Appendix 5 GDE Research approval letter Year 1

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

For administrative use:
Reference no: D2016 / 045

GDE RESEARCH APPROVAL LETTER

Date:	**22 April 2015**
Validity of Research Approval:	**22 April 2015 to 2 October 2015**
Name of Researcher:	**Woolway J.J.**
Address of Researcher:	**P. O. Box 167427; Brackendowns; Alberton; 1454**
Telephone / Fax Number/s:	**016 365 5018; 082 776 0811; 011 868 4811**
Email address:	**ijkl@mweb.co.za**
Research Topic:	**Exploring the different communicative approaches to integrate learner prior knowledge into the teaching and learning of Science concepts in Grade 8**
Number and type of schools:	**ONE Secondary School**
District/s/HO	**Ekurhuleni South**

<u>Re: Approval in Respect of Request to Conduct Research</u>

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. A separate copy of this letter must be presented to the Principal, SGB and the relevant District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted. However participation is VOLUNTARY.

The following conditions apply to GDE research. The researcher has agreed to and 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:

CONDITIONS FOR CONDUCTING RESEARCH IN GDE

1. The District/Head Office Senior Manager/s concerned must be presented with a copy of this letter;

2015/04/24

1

Making education a societal priority

Office of the Director: Knowledge Management and Research
9th Floor, 111 Commissioner Street, Johannesburg, 2001
P.O. Box 7710, Johannesburg, 2000 Tel: (011) 355 0506
Email: David.Makhado@gauteng.gov.za
Website: www.education.gpg.gov.za

2. A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB);
3. A letter / document that outlines the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned;
4. The Researcher will make every effort obtain the goodwill and co-operation of all the GDE officials, principals, SGBs, teachers and learners involved. Participation is voluntary and additional remuneration will not be paid;
5. Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal and/or Director must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage;
6. Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year. If incomplete, an amended Research Approval letter may be requested to conduct research in the following year;
7. Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.
8. It is the researcher's responsibility to obtain written parental consent and learner;
9. The researcher is responsible for supplying and utilising his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources;
10. The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations;
11. On completion of the study the researcher must supply the Director: Education Research and Knowledge Management with one Hard Cover, an electronic copy and a Research Summary of the completed Research Report;
12. The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned; and
13. Should the researcher have been involved with research at a school and/or a district/head office level, the Director and school concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.

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

Kind regards

....

Dr David Makhado

Director: Education Research and Knowledge Management

DATE: 2015/04/24

Office of the Director: Knowledge Management and Research
9th Floor, 111 Commissioner Street, Johannesburg, 2001
P.O. Box 7710, Johannesburg, 2000 Tel: (011) 355 0506
Email: David.Makhado@gauteng.gov.za
Website: www.education.gpg.gov.za

Appendix 6 GDE Research approval letter: Year 2

For administrative use:
Reference no. D2016 / 419 A
Enquiries: Diane Buntting 011 843 6503

GAUTENG PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

GDE AMENDED RESEARCH APPROVAL LETTER

Date:	**29 February 2016**
Validity of Research Approval:	**29 February 2016 to 30 September 2016**
Previous GDE Research Approval letter reference number	**D2016 / 045 dated 24 April 2015**
Name of Researcher:	**Woolway J.J.**
Address of Researcher:	**P.O. Box 167427; Brackendowns; Alberton; 1454**
Telephone / Fax Number/s:	**016 365 5018; 082 776 0811; 011 868 4811**
Email address:	**ijkl@mweb.co.za**
Research Topic:	**Exploring the different communicative approaches to integrate learner prior knowledge into the teaching and learning of Science concepts in Grade 8**
Number and type of schools:	**ONE Secondary School**
District/s/HO	**Ekurhuleni South**

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. A separate copy of this letter must be presented to the Principal, SGB and the relevant District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted. However participation is VOLUNTARY.

The following conditions apply to GDE research. The researcher has agreed to and 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:

CONDITIONS FOR CONDUCTING RESEARCH IN GDE

1. *The District/Head Office Senior Manager/s concerned, the Principal/s and the chairperson/s of the School Governing Body (SGB.) must be presented with a copy of this letter.*

2016/02/29

1

Making education a societal priority

Office of the Director: Education Research and Knowledge Management ER&KM)

2. *The Researcher will make every effort to obtain the goodwill and co-operation of the GDE District officials, principals, SGBs, teachers, parents and learners involved. Participation is voluntary and additional remuneration will not be paid;*

3. *Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal and/or Director must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.*
4. *Research may only commence from the second week of February and must be concluded by the end of the THIRD quarter of the academic year. If incomplete, an amended Research Approval letter may be requested to conduct research in the following year.*
5. *Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.*
6. *It is the researcher's responsibility to obtain written consent from the SGB/s; principal/s, educator/s, parents and learners, as applicable, before commencing with research.*
7. *The researcher is responsible for supplying and utilizing his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institution/s, staff and/or the office/s visited for supplying such resources.*
8. *The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research title, report or summary.*
9. *On completion of the study the researcher must supply the Director: Education Research and Knowledge Management, with electronic copies of the Research Report, Thesis, Dissertation as well as a Research Summary (on the GDE Summary template). Failure to submit your Research Report, Thesis, Dissertation and Research Summary on completion of your studies / project – a month after graduation or project completion - may result in permission being withheld from you and your Supervisor in future.*
10. *The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned;*
11. *Should the researcher have been involved with research at a school and/or a district/head office level, the Director/s and school/s concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.*

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

Kind regards

Makhado

....

Dr David Makhado

Director: Education Research and Knowledge Management

DATE: 2016/02/29

Appendix 7 Letter to school principal

.

Protocol Number: 2015ECE007D

The Principal
[redacted] High School
P.O. Box [redacted]

14 April 2016

Dear Mr [redacted]

My name is Jenny Woolway, I am a PhD student in the School of Education at the University of the Witwatersrand. I am doing research on exploring the use of different communicative approaches to integrate learner prior knowledge into the teaching and learning of science concepts in Grade 8.

I am inviting your Natural Sciences teachers from [redacted] High School to participate in this research. One class from each Grade 8 NS teacher who agrees to participate will be selected and these learners will be invited to participate in the research study as well. Whilst the study is focused on Grade 8 NS teachers and their learners, I would like to pilot my research instruments with a Grade 9 NS teacher and one of his/her classes.

My research involves working with Natural Sciences teachers, where I will look at how teachers include learner prior knowledge into their lessons. This will involve interviewing teachers individually at the start and end of the research project. Teachers who have agreed to participate will have their lessons video recorded. Once all teachers have had their lesson recorded, we will meet as a group and reflect on the lessons: how do teachers include learner prior knowledge in their lessons? Together we will work on lesson plans which provide learners with an opportunity to make their prior knowledge explicit. The lesson plans will also include teaching new science concepts, followed by activities for learners to work through in small groups. Teachers will teach according to the revised lesson plans, these lessons will be video recorded. Before meeting as a group, teachers will be asked to complete a questionnaire that looks at how successful the teacher found implementing the lesson plan. As a group we will reflect on the lessons, discussing what worked and what part of the lesson plan needs improvement. New and revised lesson plans will be reworked. It is hoped through this process together we will work out how to successfully integrate learner prior knowledge into Grade 8

Natural Sciences lessons. I would like to do the pilot study and the research with the Grade 8s in the third term. The study should last for 8 weeks.

The reason why I have chosen [redacted] High School is because I would like to be involved in the research and therefore I will video record me teaching my own Grade 8 class. Further, I see my research as providing professional development for the Natural Sciences teachers at [redacted] High School through two workshops (group work and communicative approaches) as well as by reflecting on and revising lesson plans.

The research participants (both teachers and learners) will not be advantaged or disadvantaged in any way. They will be reassured that they can withdraw their permission at any time during this project without any penalty. There are no foreseeable risks in participating in this study. The participants will not be paid for this study. Learners who are in a class selected for the study who do not want to form part of the study or whose parents have not given consent will be placed in the same group and these groups will not be video recorded.

The names of the research participants and identity of the school will be kept confidential at all times and in all academic writing about the study. Individual privacy will be maintained in all published and written data resulting from the study. I will make use of pseudonyms when referring to teachers and learners. I will use findings from this research to complete my thesis, write journal articles, present at conferences and make recommendations on policy. A copy of my findings will be given to the school and the Gauteng Department of Education. All research data will be destroyed between 3-5 years after completion of the project.

Please let me know if you require any further information. I look forward to your response as soon as is convenient.

Yours sincerely

Jenny Woolway Supervisors: Dr A Msimanga Prof A Lelliott
011 717 3073 011 707 3260

P.O. Box 167427
Brackendowns
1454

ijkl@mweb.co.za

0827760811

Formal Permission from Principal of School

I _______________________________________ do/do not (circle one) give permission for Jenny Woolway to conduct her research exploring the use of different communicative approaches to integrate learner prior knowledge into the teaching and learning of science concepts in Grade 8.

Participation by teachers and learners is voluntary. Teachers and learners are free to withdraw from the study at any time without any penalty or prejudice. Any sharing or publication of the research results will make use of pseudonyms, ensuring the school, teacher and learner anonymity.

_____________________ ________________________ ______________

(Print) Name Signature Date

Principal

Appendix 8 Interview schedule with teachers at the start of the research.

Remind and ask teachers if it is ok to audio record the interview. Also remind them that everything said is confidential and that pseudonyms will be used. Pleased they have agreed to work on the project together, hope it will be of value to all of us and that we have fun and develop as better teachers after all is said and done.

1. How long have you been teaching for?
2. How long have you been teaching Natural Sciences for?
3. Where did you do your training as a teacher?
4. What qualifications have you obtained?
5. Did you attend CAPS training? When, how long was it ?What is your understanding of the type of teaching the DoE envisages?

6. When structuring your first lesson on a new section of work, for example micro-organisms, please explain how you would go about teaching it.

Probing Questions:

- How much of the lesson would you say you spend teaching the content or explaining activities?
- What do the learners in your class do during class time?
- Do your learners have an opportunity to speak? If so when: for instance to answer your questions, ask questions, add to the class discussion or during group discussions?
- When learners are busy with activities, do they do this quietly? At home? In groups?

7. When structuring that first lesson on a new section of work, how often would you say that you ask learners to explain what they understand about the topic **before** it is taught? Mostly, sometimes, never?

Probing Questions:

'Their understanding' can be in terms of 'home knowledge' or 'science knowledge' they learnt from a previous grade.

- What do you do if a learner gives you an answer that:

(a) You didn't expect

(b) Would be considered to be 'home knowledge' or a 'cultural belief' and not necessarily scientific correct?

- If you usually do not ask learners for their understanding of the topic please explain what your reasons may be to decide against using this teaching strategy?

8. Please explain the value (if any) you place on finding out learner's ideas before a new section of work is taught?

Probing Question

- If you have, please provide an example of how you would do this?
- How many learners would you say have the opportunity to put forward their ideas? Please give more detail on how you select these learners.

9. Please describe a typical group work activity in your class.
Probing Questions:

- When do your learners work in groups?
- If a group is made up of 4 learners, how many learners do you think are making contributions?
- How do learners report back following a group work activity?

10. Is there anything else you want to add about the ways learner's own knowledge contributes to your teaching of science.

Appendix 9 Interview Schedule 2

Interview End of Year 1

Let's consider the lesson Effects of electricity:

I have a worksheet here to help remind us what we did.

1. What parts of the lesson sequence would you regard as having resulted in meaningful learning?
   Probing questions:

   Please give examples to explain what you mean.

2. What parts of the lesson sequence do you think resulted in little learning taking place?
   Probing questions:

   Why do you think this part of the lesson was unsuccessful?

3. What are your thoughts of moving between teacher's talking/ learner listening to learners talking/teacher listening when teaching new concepts?
4. How effective do you think it was having learners talk about activities in small groups?
   Probing questions:

   How much of the time do you think learners spent on task?

   How much learning actually took place?

   Would you continue to use small groups in your teaching next term?

5. How easy/difficult did you find incorporating learners prior knowledge in your lesson sequence?
   Probing Questions:

   Please give me example to explain what you mean.

6. What parts of the lesson plan, would you consider helped to contribute to effective teaching and learning?
7. Could you recommend ways in which the lesson may be improved, so that it could be used when teaching the same content next year?

Let's look at the light worksheet.

8. What was your experience of the research methodology, i.e. planning new lessons based on reflections from previous lessons? Please explain your answer

9 Is there anything else you would like to comment on regarding your experiences of participating in the research?

Appendix 10 Interview Schedule End of Year 2

1. What parts of the lesson sequence would you regard as having resulted in meaningful learning?
   Probing question
   Please give examples to explain what you mean.

2. What parts of the lesson sequence do you think resulted in little learning?
   Probing Question, why do you think this part of the lesson was unsuccessful?

3. What are your thoughts on moving between teachers talking, learners listening to learners talking teacher listening?

4. How effective, in terms of meaningful learning, do you think it is to have learners talk in small groups?
   Probing question:
   How do you know that learners have discussed the work correctly?

5. Having gone through the whole research process, knowing that it looked specifically at including LPK into lessons.

(a) What do you understand by LPK?
(b) Where do learners get this kdge from?
(c) Do you think it is worthwhile to spend time exploring LPK in your lessons?
(d) How would you go about finding out about what kdge the learners have? What are the other learners in the class doing?
(e) What factors do you think allow teachers to include LPK into our lessons.
(f) What factors do you think prevent some teachers from working with LPK.
(g) How would you go about working with LPK where there is a misconception?

7. We have worked together quite intensively on the effects of current and the light section of work as a professional development group.
   Please tell me what you sorts of things you may have gained by being part of the group, if any?
   What were your frustrations while doing the research?

Which two sections of work from next year would you like to rework in a similar way?

8. Is there anything else you would like to comment on regarding your experiences of participating in the research?

Appendix 11 CAPS Natural Sciences: Effects of an Electric Current.

(Department of Basic Education, 2011b)

TIME	TOPIC	CONTENT & CONCEPTS	SUGGESTED ACTIVITIES: INVESTIGATIONS, PRACTICAL WORK, AND DEMONSTRATIONS	EQUIPMENT AND RESOURCES
	Energy transfer in electrical systems *[continued…]*	**Components of a circuit** *[continued...]* • **resistors** are made of materials that resist/oppose the flow of electrical current in a circuit - resistors in a circuit have an influence on the amount of electric current flowing in that circuit - some resistors (including bulb filaments, heating wires, elements in kettles/heaters/geysers/stoves) can heat up to provide useful output energy o a light bulb such as a torch bulb, contains a resistance wire called a filament. The filament heats up to be white hot when connected in a circuit. The resistance wire is connected to two contact points – the one end to the screw part (casing) and the other end to the solder knob at the bottom. The two contacts are separated by an insulator		
		Effects of an electric current • a current can heat a resistance wire (such as a bulb filament) - an electrical current transfers energy to the particles in a bulb filament, producing light that the filament emits - circuits can overheat if a short circuit occurs: o **fuses** are special wires which break the circuit when they overheat and melt. These are safety devices that reduce the danger when using electricity o **a short circuit** can occur when an electric current takes the path of lowest resistance, for example when a conductor is connected directly to both terminals of a cell/battery • a current causes a magnetic field (such as in electromagnets) - an electric current can be used for making temporary magnets known as electromagnets. Moving charges (current) in a conductor (such as a wire), cause a magnetic field around it • an electric current can cause a chemical reaction in a solution, this process is called electrolysis - water can be broken down by electrolysis to produce oxygen and hydrogen gas - copper(II) chloride solution can be broken down to copper metal and chlorine gas. Copper is deposited on one electrode (cathode) and chlorine gas is formed as bubbles at the other electrode (anode)	• **reading** about how fuses work • **investigating** the heating effect of a current by using a resistance wire (such as a strand of steel-wool/ nichrome wire) - observe, record and write about the effect - predict or interpret information about other applications • **investigating** the magnetic effect of a current in a wire bent into a coil - observe and record its effect on a magnetic compass - predict or interpret information about other applications • **investigating** electrolysis of copper(II) chloride solution - observe and record what happens - predict or interpret information about other applications	• Cells/batteries • Circuit boards • Torch bulbs • Switches • Resistors (steel wool or nichrome wire) • Copper wires • Steel wires • Copper(II)chloride • Magnetic compasses • other (available) input and output devices

Appendix 12 CAPS Natural Sciences: Light

(Department of Basic Education, 2011b)

TIME	TOPIC	CONTENT & CONCEPTS	SUGGESTED ACTIVITIES: INVESTIGATIONS, PRACTICAL WORK, AND DEMONSTRATIONS	EQUIPMENT AND RESOURCES
3 weeks	**Visible light**	**Radiation of light** • light is emitted from luminous objects such as the Sun and light bulbs, and is transferred by radiation • light travels in straight lines • light travels through empty space at a speed of 300 000 kilometres per second (the distance from the Sun to Earth is 150 million kilometres) *(refer to Grade 7 Energy and Change)*	• **drawing** a ray diagram to explain the image formed in the tissue paper at the back of the pinhole camera *[Teacher can demonstrate using a pinhole camera]*	• Video clips from the internet about the electro-magnetic spectrum • Pinhole camera (if available) • Cardboard box (shoe box) • Tissue paper • Glue
	Visible light *[continued...]*	**Spectrum of visible light** • white light consists of a spectrum (range) of different frequencies and wavelengths – violet, indigo, blue, green, yellow, orange, red. All these colours make up the spectrum of visible light ***[Note:** NO further detail on wavelengths and frequencies is required at this level]* • a rainbow is seen when light falls on water droplets in the air and is refracted and dispersed into the different colours (violet, indigo, blue, green, yellow, orange, red) seen in the rainbow • the light at the violet, indigo, blue range of the spectrum has the highest frequency (shortest wavelength) and orange and red light has the lowest frequency (longest wavelength)	• **observing and recording** the sequence of colours in the visible spectrum when light is shone through a triangular prism	• Pin • Tinfoil (to make a pinhole camera) • Light source • Cardboard with narrow slit • Triangular prism
		Opaque and transparent substances • light cannot pass through opaque surfaces (such as metal, clay, bricks, wall paint, cardboard), therefore it is either absorbed or reflected • opaque substances cast shadows on the side facing away from the light source • light passes through transparent substances (such as glass, clear plastic, cellophane, clean water), therefore some of the light is absorbed, some is reflected, but most passes through	• **drawing** diagrams to show how shadows are cast by opaque objects. • **predicting** effects of moving the object (such as a cardboard shape) closer or further away from the light source	• Light source • Cut-out cardboard shapes

Appendix 13 Learner Notes from Cycle 2

The effects of an electric current

Name: ____ Class:_______

Note:

Electricity, if not used correctly is dangerous,
treat all wires or connections as being alive.
Electric wires are sharp and can stab into you if you are not careful.
Insulation must be removed from wires where connections are to be made to batteries or each other.

The flow of electric charges (electrons) through a conductor causes three distinct effects.

We call these the **Effects of an Electric Current**.

Working in groups answer the following questions:

1. What is purpose of electric wire?

2. Why are wires covered with "insulation" material?

3. Name three different uses for electricity in your home.
   a.
   b.
   c.

4. Name the three effects of an electric current
   a.
   b.
   c.

5. What is meant by a "coil of wire"

6. Explain what is meant by a magnetic material. (not magnet)

Practical Activity

The aim of these activities is to look at the electromagnetic effect of electricity.

Materials needed

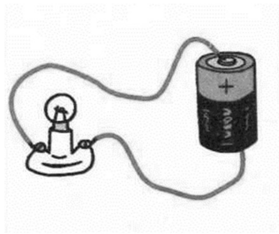
a. A large battery (cell)
b. Lengths of insulated copper wire
    a. Plastic insulated: - 100mm
    b. Varnish insulated: - 1m
c. Large Steel nail
d. Small pieces of metal: copper, iron, brass
e. Compass (N,S,E,W)
f. Small Lamp.
g. Electrical DC Power supply. (Small A4 cells)
h. Small magnet
i. Prestik

1) Use the small magnet to test which of the small pieces of metal are magnetic. Complete the following table:

Table showing which items are magnetic and which are not magnetic

Magnetic	Not magnetic

2) Try to lift the copper wire using the magnet. Does the magnet attract the copper wire? Is copper wire magnetic?
3) Can we get magnetism from a wire?
    a) Remove 10mm of the insulation from the ends of the plastic insulated wire.
    b) Connect the wire to the lamp and cell as indicated in the diagram below.



c) Is the lamp working? _____________. If not why? ________________

d) Open the circuit. Place the compass under the wire about half way between the ends of one of the plastic insulated wires.

e) Look at the compass needle while you switch the circuit on again. What do you observe?

____

f) Open the circuit leaving the compass under the wire, swop the connections to the cell. Switch the circuit "ON" again.
What do you observe happens to the compass needle?

____

g) Write down a conclusion for this investigation.

____

4) <u>Make an electro-magnetic. (use the varnish insulated wire)</u>

a) Leaving 150mm of the wire free, wrap the rest of the wire around the nail, leaving 150mm of the wire free at the end.

b) Tie a knot to prevent the wire from unravelling.

c) Scrape 15mm of the insulation off both ends off the wire. Ensure the copper is seen all the way around.

d) Loop the ends of the wire to make a larger contact area.

e) Hold the looped ends against the terminals of a cell.

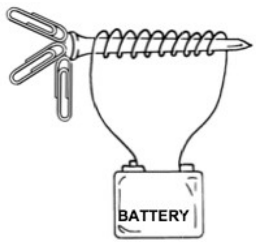
f) Bring the compass closer to the flat end of the nail. Describe what happens:

____

g) Try picking up some metal objects with the electro-magnet. Name the materials which can be picked up by magnetism.

Write down your conclusion

Class Competition



.

Using the various components that were supplied to your group, make the strongest electro magnet.

We will measure the strength of the electro magnet by the length of a paperclip chain that can be picked up.

Appendix 14 Learner Notes from Cycle 3

Light

Activity 1

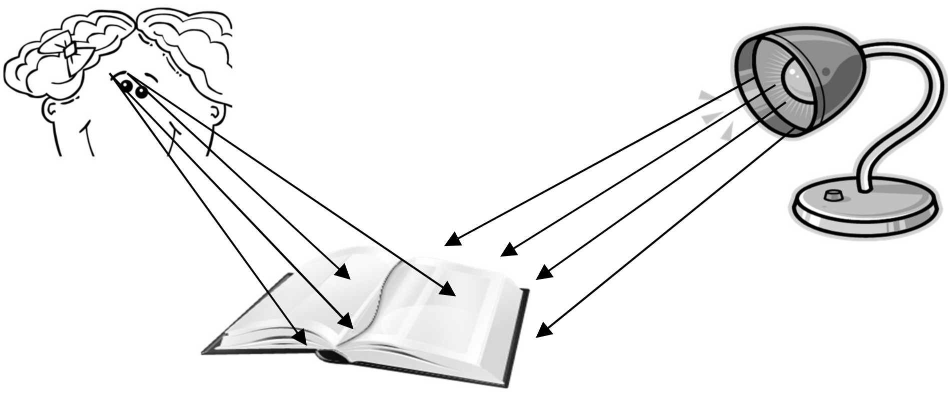
1. (a) Draw a diagram of this candle  burning in a dark room.

(b) Show in your diagram how you think the light behaves.

2 How would the light from the candle behave if the room wasn't in darkness?

Activity 2

Mpho and Steve made the following drawing:



They wrote the following about their drawing…

"The light shines on the book. Kate looks at the book and sees the book because the light is shining on it."

2.1 What part of their diagram is correct?

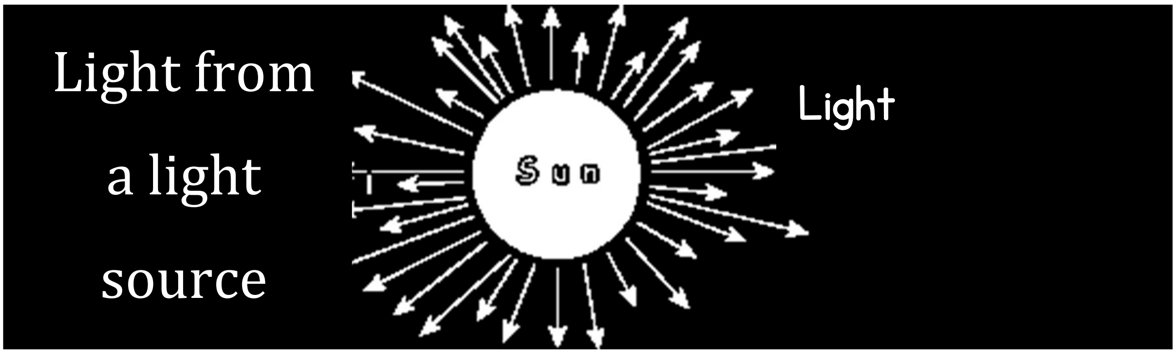
2.2 Fix the part of their diagram that is incorrect.

2.3 Explain why you changed their diagram. -----------------

So where does light come from and how does it behave?

1. Some objects give off (emit) light, for example the sun and a light bulb. The light may come from chemical reactions that are so hot, light is released. These objects are said to be luminous.

2. Light travels in straight lines.



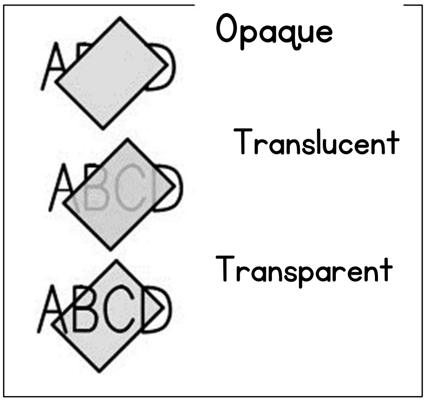
3. Light moves very quickly 300 000 km per second. (That is much faster than the fastest bullet).

4. When light hits objects it behaves in various ways depending on the properties of the object.

(a) If the light cannot pass through an object, we say the object is opaque. The light has been absorbed.

(b) If some of the light moves through an object, we say the object is translucent.

(c). If most of the light moves through an object, we say the object is transparent.



Activity 3

Write down at least 3 objects in the class that are opaque, translucent and transparent.

Opaque: ____

Translucent: ____

Opaque ____

Opaque objects cast shadows on the side facing away from the light source, as the light has been blocked.

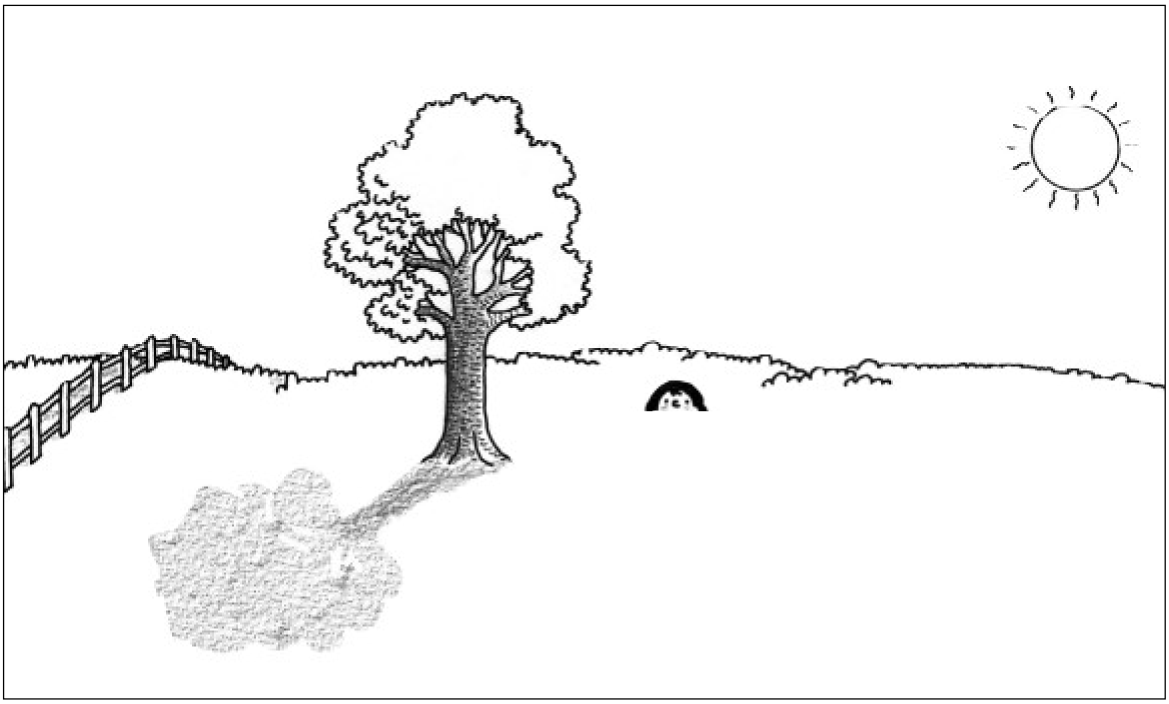
Activity 4

Observing your shadow.

For this activity your teacher will take you outside. You are required to work in pairs. Draw a diagram of your friend and his/her shadow.

You need to pay attention to:

1. Where the sun is.
2. Where the shadow falls.
3. Use the diagram rules you were taught at the beginning of the year.
4. You can draw your friend and his/her shadow in the diagram below.



5. Add light rays from the sun to show how the shadow is formed.

How does light travel ?

You are going to make a pinhole camera to help you understand how light moves and how we draw this.

A pinhole camera is a very simple camera: it is made of a dark box, which has a screen on one side and a very small opening (made by a pin) on the other. The smaller the hole the clearer the image on the screen.

Activity 5

Apparatus:

Cut out template	A pair of scissors	Tape
Glue	Wax proof paper.	Pin

1. Stick the template of the pinhole camera on a piece of cardboard.
2. Cut out the template of the pinhole camera. Cut only on the solid lines. Remember to cut out the window box on the one end.
3. Cut out a piece of wax paper and stick it over the cut out window. This will act as the screen for the camera.
4. Using a pin, make a hole in the centre of the circle on the template.
5. Fold the template on the dotted lines.
6. Stick down the numbered tabs, to make your camera. Make sure it is tightly stuck. No light must enter inside the camera.
7. Have a look at a burning candle through the viewing end of the camera.

6. Draw a diagram in the box on the next page of what you see.

Diagram of actual object	Diagram of object on screen of the pinhole camera

Questions

5.1 What is different between the actual object and the image on the screen on the pinhole camera?

-

5.2 Use your Textbook page 132, to draw a ray diagram which shows you how light behaves as it moves through your pinhole camera.

The ray diagram helps to explain why...

1. The image on the screen is smaller than the original object.
2. The image is upside down.

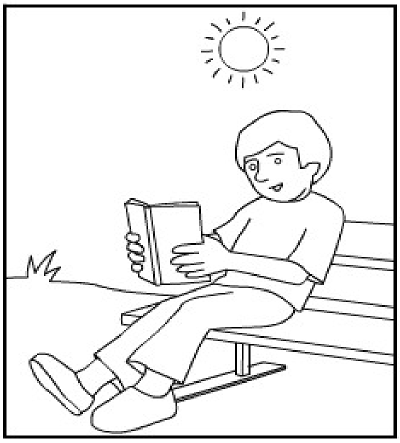
Activity 6 How we see things

Draw arrows (representing light) on the pictures below to show how:

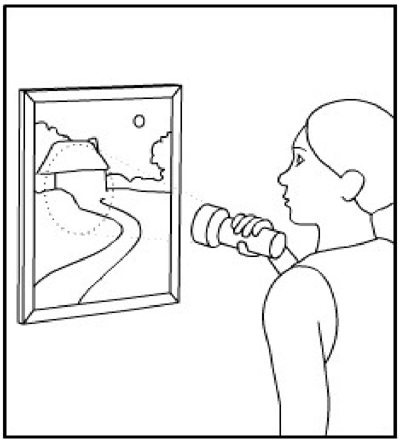
6.1 The boy can see the page of the book he is reading.

6.2 The girl can see the picture on the wall.

a)



b)



Activity 7

What happens when light hits something?

Complete the activity below by solving for the missing letters and then answer the question below the puzzle.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
10				4	11			15				23		26								9			

W _ E _   _ I _ _ _   _ I _ _   A _   O _ _ E _ _ ,
9 3 4 24   8 15 18 3 7   3 15 7 2   10 24   26 22 21 4 20 7

_ I F F E _ E _ _   _ _ I _ _ _   _ A _   _ A _ _ E _
16 15 11 11 4 6 4 24 7   7 3 15 24 18 2   20 10 24   3 10 17 17 4 24

_ O   I _   _ E _ E _ _ I _ _   O _   W _ A _   _ _ E
7 26   15 7   16 4 17 4 24 16 15 24 18   26 24   9 3 10 7   7 3 4

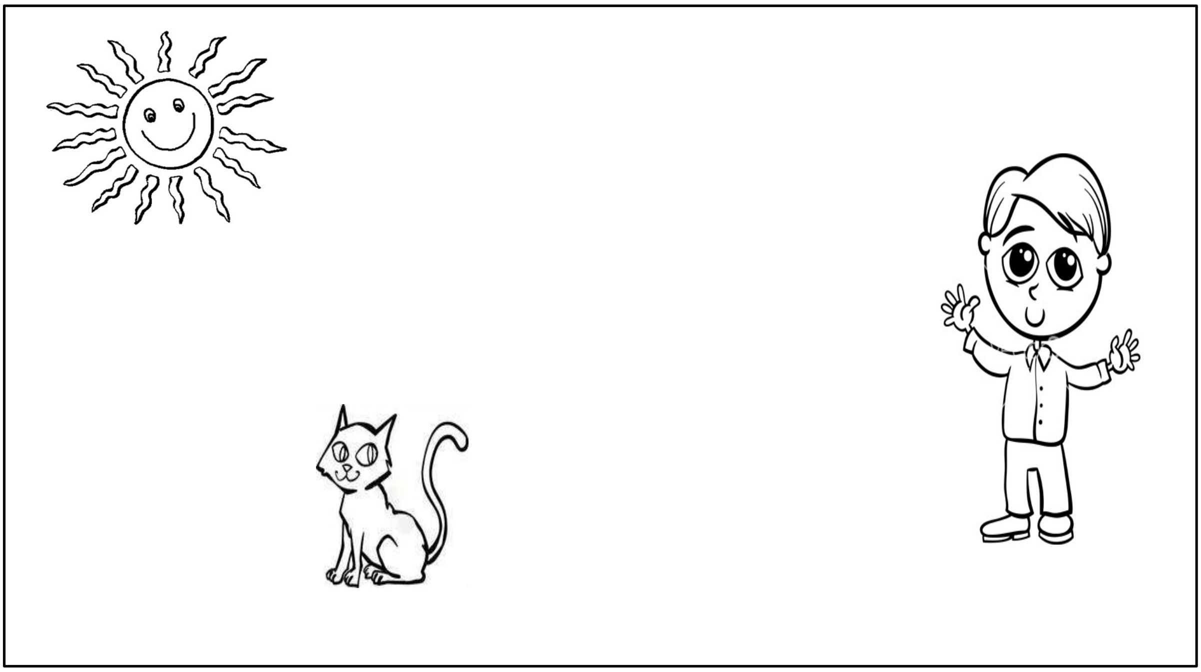
O _ _ E _ _   I _   M A _ E   O _ _   O F .
26 22 21 4 20 7   15 2   23 10 16 4   26 1 7   26 11

Make a list of these things below:

T_________
A_________
R_________
B_________

Activity 8

8.1 Add light rays to the picture below, showing how the boy sees white cat.



8.2 Draw in the shadows of the cat and boy.

8.3 Write a few sentences to explain what is going on. In your explanation use the following key words:

Opaque, Light, Sun, Luminous, Shadow.

____

____

____

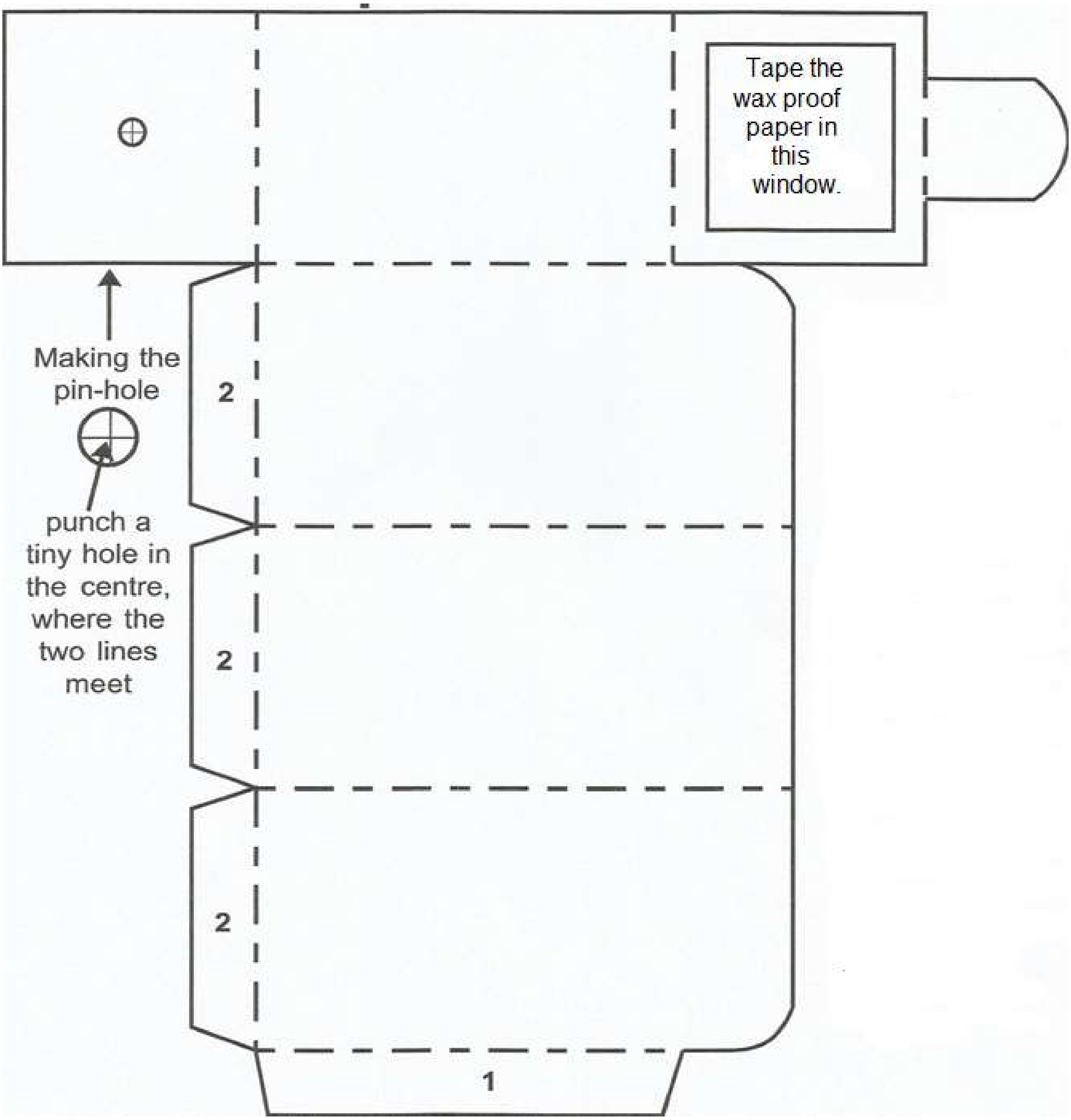
____

____

____

____

Pinhole Camera Template



Lesson Plan on Effects of electricity

CAPS Policy

Effects of an electric current

• a current can heat a resistance wire (such as a bulb filament)

-- an electrical current transfers energy to the particles in a bulb filament, producing light that the filament emits

-- circuits can overheat if a short circuit occurs:

conductor is connected directly to both terminals of a cell/ battery

• a current causes a magnetic field (such as in electromagnets)

-- an electric current can be used for making temporary magnets known as electromagnets. Moving charges (current) in a conductor (such as a wire), cause a magnetic field around it

• an electric current can cause a chemical reaction in a solution, this process is called electrolysis

-- water can be broken down by electrolysis to produce oxygen and hydrogen gas

-- copper(II) chloride solution can be broken down to copper metal and chlorine gas. Copper is deposited on one electrode (cathode) and chlorine gas is formed as bubbles at the other electrode (anode)

	Day 1					
	Activity	**Learner**	**Teacher**	**Resources**	**Time**	**Comments**
*	Demographic questionnairre.	Complete		Questionnairre	10 min	
*	Hand out "Effects of Electric current worksheet"	Complete activitiy 1 for home work.	Hand out worksheets. Do NOT pre empt any answers. Learners may use whatever resources they like: notes, textbooks, internet etc.	Effects of electricity worksheet.	5 min	

	Day 2					
	Activitity	**Learner**	**Teacher**	**Resources**	**Time**	
1		Working in groups discuss the completed homework.	Move between groups, prompting deeper meanings.	Notes	15 Min	
	Report back on actictivity	Give answers to questions.	Go through questions asking learners for responses.	Notes	10 min	
2	**Chemical Effect of an Electric Current**	Watch video on electrolysis of Copper chloride.In groups answer the questions: Activity 2.	Explain what is happening during the video. Explain the purpose of the lamp is to show that current is flowing through the circuit.Go through learner responses.	Video	35 Min	
	Day 3					
	Activitity	**Learner**	**Teacher**	**Resources**	**Time**	
		1. Working in groups identify various pieces of apparatus.	1. Go through all the apparatus in the boxes except the bag with the metals. Tell the learners they will be using that bag in the next lesson. Draw attention to how to put cells in the battery holder. Compasses and magnets need to be handed out separately. Show learners which are which.	1. Boxes with electrical compnents.	10 min	
3	Heating Effect of an Electric Current	2. Set up a circuit with a lamp and notice the heating effect. Answer questions 1 - 4	Go to groups asking questions to help learners make meaning		30 min	

4	Magnetic Effect	3. Using the circuit already set up, learners push a compass under a wire to notice the magnetic effect. Answer questions	Move between groups, probing their understanding as to the link between the deflection on the compass needle indicating there is a magnetic field.		20 min	
Day 4						
5	Invetstigation on which materials are magnetic	1. Learners use magnets to determine which metals are magnetic.	Move between groups asking probing questions, linking the idea that in the last lesson the copper wire connected to a circuit had a magnetic field, but copper wire on it's own is not magnetic.	Box with electircal components	20 min	
6	Build the strongest electro magnet competition.	2. Learners need to think about what they can do to make their electromagnets strong.	Move between groups asking learners what they did to get their magnets stronger. Emphasize the importance of removing all insulation from ends of connection wires.		30 min	

Day 5						
7	Complete the concept map	1. Working in pairs learners complete the concept map linking the work togethers.	1. Move between learners probing understanding	Notes	15 min	

Appendix 16 Learner Notes from Cycle 4

The effects of an electric current.

Name: ______________________________ Class:_______

1. Electricity, if not used correctly is dangerous, treat all wires or connections as being alive.

2. Electric wires are sharp and can stab into you if you are not careful.

3. Insulation must be removed from wires where connections are to be made to batteries or each other.

Activity 1

15 min

Answer the following questions:

1. What is the purpose of electric wire?

____

2. What is insulation?

____

____

3. Give TWO reasons why we insulate electric wires?

____

____

4. Name three different uses for electricity in your home.

a. ______________________________

b.

c.

5.Name the three effects of an electric current

a.

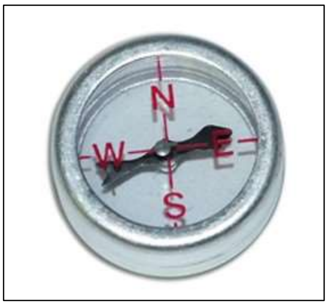
b.

c.

6 What is meant by a “coil of wire”? Draw a diagram to help your explanation.

7. Explain what is meant by a magnetic material. (Do not define the term ‘magnet’)

8. Questions 8 (a) -(c) refer to the diagram below:



a. Name this piece of apparatus.

b. Name TWO of its uses.

c. How does this piece of apparatus react when there's a magnetic field?

Activity 2

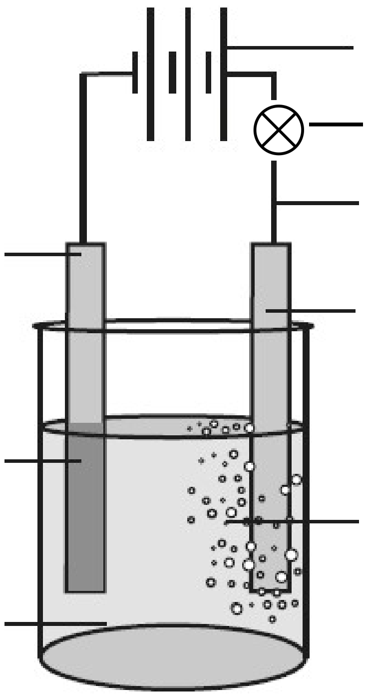
35 min

The Chemical Effect of an Electric Current

Watch the video showing electrolysis of Copper Chloride and answer the questions that follow:

1. **Label the diagram below.**

<u>Diagram showing the breakdown of Copper Chloride using electrolysis.</u>



2. **Why was the light included in the circuit?**

---

3. **Explain the results of the experiment.**

----

4. Which effect of an electric current caused the Copper Chloride to split into copper and chlorine?

----

10 minutes

Check electrical kits.

Activities 3 – 6 require you to use various electrical components.
Your group will be provided with a kit.
Make sure you know what each component is in your kit. You need to mark it off on the check list.

1. X2 cells
2. Length of plastic insulated copper wire
3. Large Steel nail
4. Small pieces of metal: copper, iron, brass, aluminium
5. 2 Small Lamps and 2 lamp holders
6. Battery holder
7. Prestik

8. X4 Lengths of cable with crocodile clips.
9. X 15 Paper Clips

Activity 3 **Time: 30 min**

The Heating Effect of an Electric Current

AIM:

To demonstrate the heating effect of an electric current.

METHOD:

1. Connect a circuit with the following components: 2 cells, cables with crocodile clips and a light bulb.

2. Draw and label the circuit diagram in the space below.

3. What TWO observations can you make about the light bulb when the circuit is closed?

----

4. Which effect of electric current is causing the lamp bulb to glow?

Activity 4 **Time: 20 min**

The Magnetic Effect of an Electric Current

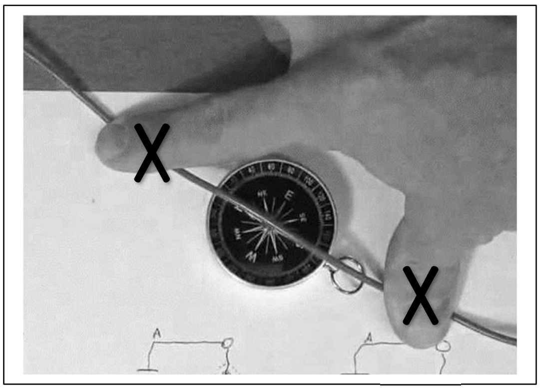
AIM:

To demonstrate the magnetic effect of an electric current.

Method

1. What do you notice happens to the needle of the small compass when it comes in contact with a magnet?

   ----
2. Using the circuit you have connected in Activity 3. Place the small compass under one of the connecting wires as shown below.



3. Prestik the wire on either side of the compass (as shown by the points marked 'X' in the picture above) to your desk, so that the wire is tight over the compass.

<u>Questions for Activity 4</u>

a) Look carefully and write down what happens to the needle of the compass when you close the circuit?

----

b) Why does the needle of the compass behave in this way?

----

c) What effect of electric current is being demonstrated?

----

d) What do you notice happens to the compass needle if you swop the wires around at the battery holder? Look carefully.

ACTIVITY 5

Time: 20 min

Aim: To determine which metals are magnetic.

Method:

1. Use the small magnet to test which of the small pieces of metal (aluminium, brass, copper, iron) in the small plastic bag are magnetic.

Results:

Complete the table below:

Table showing which metals are magnetic and which are not magnetic

Magnetic	Not magnetic

Conclusion:

You will have observed in Activity 4 that when copper wire was connected to a closed circuit it caused the compass needle to move, indicating that there was a magnetic field around the copper wire. Yet in this investigation you will have observed that copper is NOT magnetic. Explain the difference in these results.

ACTIVITY 6

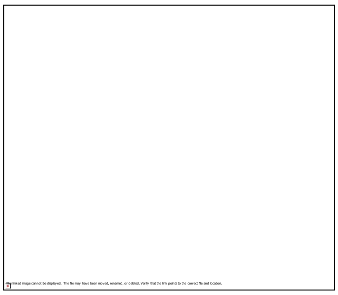
Time: 30 min

AIM: To build the strongest electro magnet in the class.

METHOD:

1. Think back to your Primary School days in Technology, where you built an electro magnet using a nail, piece of

wire and a cell. Your electro magnet probably looked something like the diagram below:



2. This year however you are required to try and build the strongest electro magnet in the class.
3. In your group write down TWO possible ways you can increase the strength the length of electro magnet.

   ____

   ____
3. Use the plastic insulated wire, nail and cells to make your electro magnet.
4. You are NOT allowed to link the paper clips, they must be free. The record last year was 7 paper clips.
5. Please uncoil the wire from the nail at the end of the practical so the next group does not benefit from your hard work. Wrap the wire in the same way you found it wrapped up.
6. Our group picked up _______ paper clips.

ACTIVITY 7

Time: 30 min

Complete the mind map below:

Uses of Electricity	What does it do?	Effect of Electric Current
1. Speaker	1. Sound	1.Magnetism
2. Kettle	2.	2.
3. Charge your phone	3.	3.
4. Lights	4.	4.
5. Stove	5.	5.
6.	6.	6.
7.	7.	7.

Effects of Electric Current

	1.	2.	3.
We know this because			

Appendix 17 Lesson Plan Light Year 2

Lesson Plan on Light

	Day 1					
	Activitity	**Learner**	**Teacher**	**Resources**	**Time**	**Comments**
*	Activity 1	Working in pairs learners complete Activity 1: Drawing diagrams and writing explanations for how they think light behaves when a candle burns in the day and night.	Hand out new notes. Ask learners to work in pairs completing Activiity 1	Notes	30 min	
*	Activity 2	Working in pairs learners complete Activity 2.	Before learners complete activity 2 explain that light is either emitted or reflected off objects and that is why we see. Then let learners complete activity 2 in pairs. When completing activitiy 2 walk around and ask probing questions: Why did you draw that? Explain what you mean. Is that correct, why? Once activity completed go through correct answers with learners in a Q nd A.	Notes	30 min	

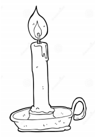
	Activity	Learner	Teacher	Resources	Time	Comments
	DAY 2					
	Activity	**Learner**	**Teacher**	**Resources**	**Time**	**Comments**
	Terminology	Listen to teacher explanation	Using PPT explain what is meant by: luminous, opaque, translucent and transparent. Show video which explains how fast light travels, comparing it to the speed that a bullet moves.	PPT	20 min	
	Activity 3	Working in pairs learners complete Activity 3.	Walk around asking probing questions. After 5 minutes report back ensuring learners have understood the terms. Explain how shadows form.	Notes	10 min	
	Activity 4	Working in pairs learners complete Activity 4 observing their partner's shadow.	Walk around making sure learners are noting where the sun is, how their shadow falls and the direction and size of their shadow.	Notes, cloudless day.	30 min	
	Day 3					
	Activity	**Learner**	**Teacher**	**Resources**	**Time**	**Comments**
	Activity 5 Build a pinhole camera	Each learner builds their own pinhole camers and comletes the diagrams of page 6 on the notes.	Give clear instructions as to how to build the camera. Walk around and help learners as needed.	Template for pinhole camera. Black Paper Scissors Glue Tape	1 hour	

	Activity 5.2	Working in pairs learners draw a ray diagram showing why their image was upside down.	Teacher walks around probing learner understanding.	Textbook	30 min	
Day 4						
	Pg 8 Activity 5.2	In their pairs learners explain why the image from the pinhole camera appeared upside down and was smaller.	walk around probing learner understanding. Perhaps give one or two groups the chance to report back to the rest of the class.	Textbook	15 min	
	Activities 6,7 and 8	Working in pairs complete the revision activities.	Walk around between the pairs probing learner understanding.Allow 10 minutes to do a whole class discussion going through learner responses.	Notes	40 min	

Appendix 18 Learner Notes from Cycle 5

Light

Activity 1

1. (a) Draw a picture of this candle  burning in a dark room, in the box below.

- Do NOT shade any part of your picture.
- Your picture need NOT follow the rules for drawing a scientific diagram.

Picture of a candle burning in a dark room.

(b) Add arrows to your picture showing how you think the light behaves.

2 (a) Draw a picture of the same candle, this time burning in a room during the day, in the box below.

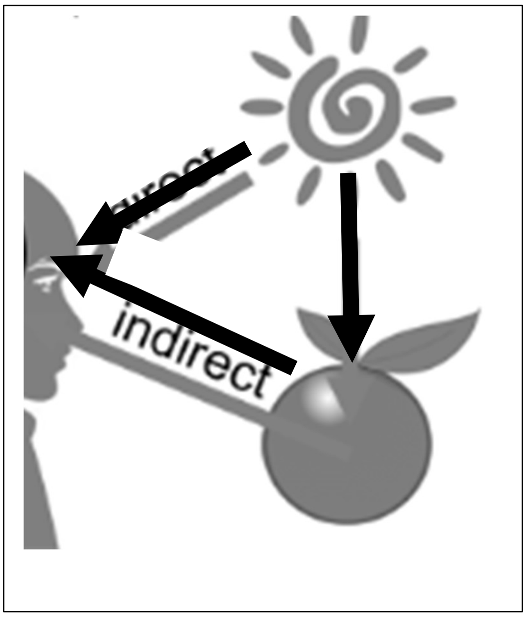
3. Explain how you think the light behaves:

(a) In a dark room.

(b) In a light room.

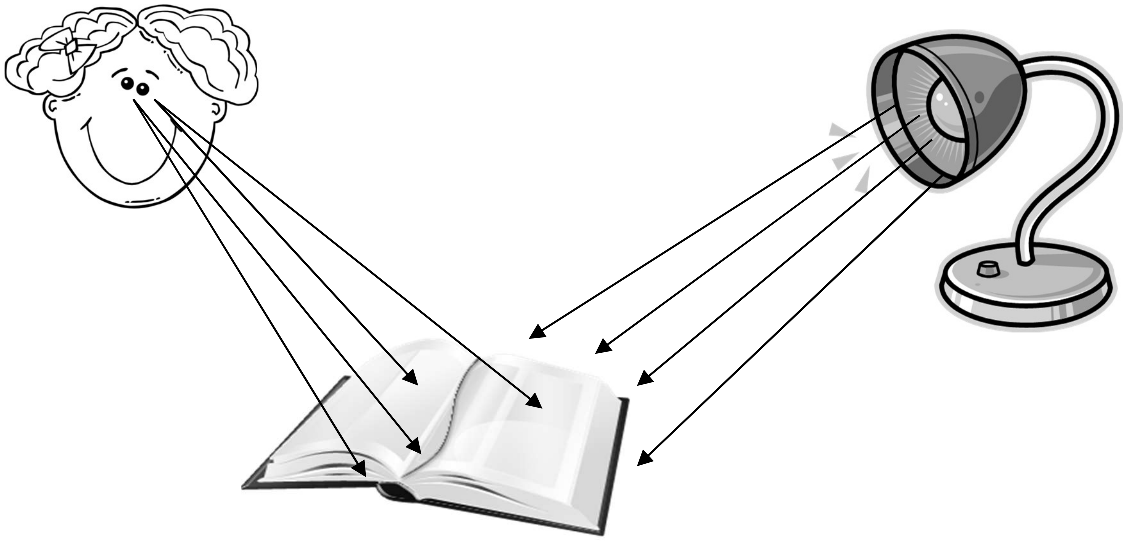
The reason why you are able to see light is that either an object is emitting or reflecting light. This means that light travels into your eyes from an object.

We use straight line arrows to show the way light moves: these lines are called rays.



Activity 2

Mpho and Steve made the following drawing:



They wrote the following about their drawing…

"The light shines on the book. Kate is able to read because the light moves from her eyes to the book".”

2.1 What part of their picture is correct? ---

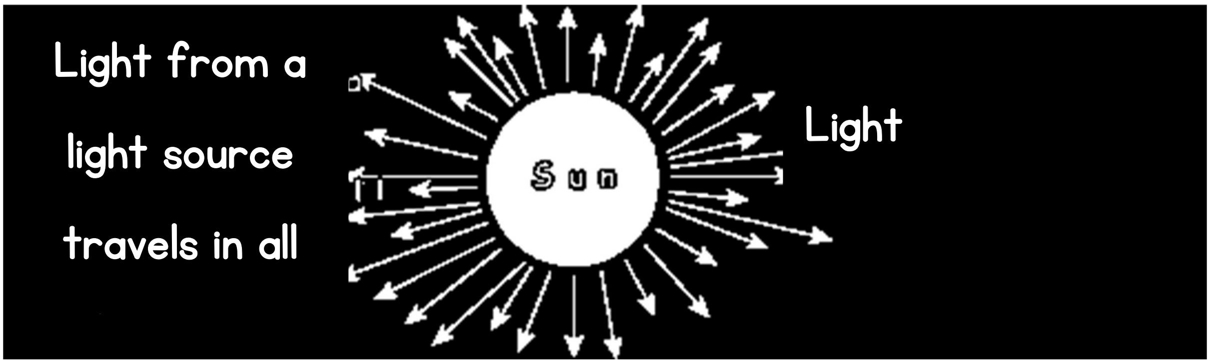
2.2 Fix the part of their picture that is incorrect.

2.3 Explain why you changed their picture

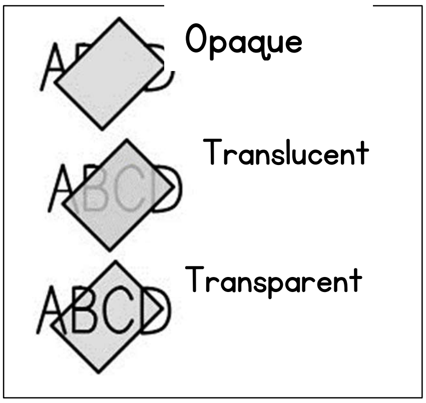
. ---

So where does light come from and how does it behave?

1. Some objects give off (emit) light, for example the sun and a light bulb. The light may come from chemical reactions that are so hot, light is released. These objects are said to be luminous.
2. Light travels in straight lines.



3. Light moves very quickly 300 000 km per second. (That is much faster than the fastest bullet).
4. When light hits objects it behaves in various ways depending on the properties of the object.



(a) If the light cannot pass through an object, we say the object is **opaque**. The light has been absorbed.

(b) If some of the light moves through an object, we say the object is **translucent**.

(c). If most of the light moves through an object, we say the object is **transparent**.

Activity 3

Write down at least 3 objects in the class that are opaque, translucent and transparent.

Opaque: --

Translucent: ______________________________________

Transparent______________________________________

Opaque objects cast shadows on the side facing away from the light source, as the light has been blocked.

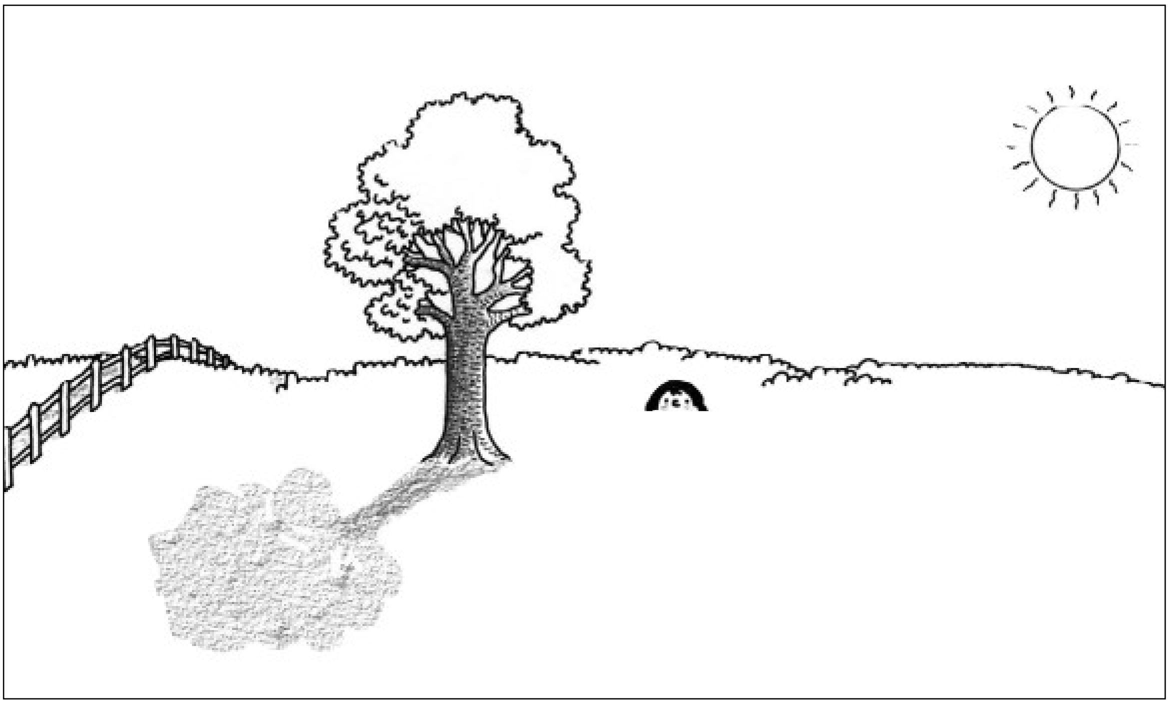
Activity 4

Observing your shadow.

For this activity your teacher will take you outside. You are required to work in pairs. Draw a diagram of your friend and his/her shadow.

You need to pay attention to:

1. Where the sun is.
2. Where the shadow falls.
3. Use the diagram rules you were taught at the beginning of the year.
4. You can draw your friend and his/her shadow in the diagram below.



5. Add light rays from the sun to show how the shadow is formed.

How does light travel?

You are going to make a pinhole camera to help you understand how light moves and how we draw this.

A pinhole camera is a very simple camera: it is made of a dark box, which has a screen on one side and a very small opening (made by a pin) on the other. The smaller the hole the clearer the image on the screen.

Activity 5

Apparatus:

Cut out template	A pair of scissors	Tape
Glue	Wax proof paper.	Pin

1. Stick the template of the pinhole camera on a piece of black paper.
2. Cut out the template of the pinhole camera. Cut only on the solid lines. Remember to cut out the window box on the one end.
3. Cut out a piece of wax paper and stick it over the cut-out window. This will act as the screen for the camera.
4. Using a pin, make a hole in the centre of the circle on the template.
5. Fold the template on the dotted lines.

6. Stick down the numbered tabs, to make your camera. Make sure it is tightly stuck. No light must enter inside the camera.
7. Have a look at a burning candle through the viewing end of the camera.
6. Draw a diagram in the box on the next page of what you see.

<u>Diagram of actual object</u>	<u>Diagram of object on screen of the pinhole camera</u>

Questions

(5)

5.1 What is different between the actual object and the image on the screen on the pinhole camera?

____ (1)

5.2 Use your Textbook page 132, to draw a ray diagram which shows you how light behaves as it moves through your pinhole camera.

(6)

The ray diagram helps to explain why…

1. The image on the screen is **smaller** than the original object.
2. The image is **upside** down.

In your own words explain why the image appears upside down and smaller.

____

____

____

____

____

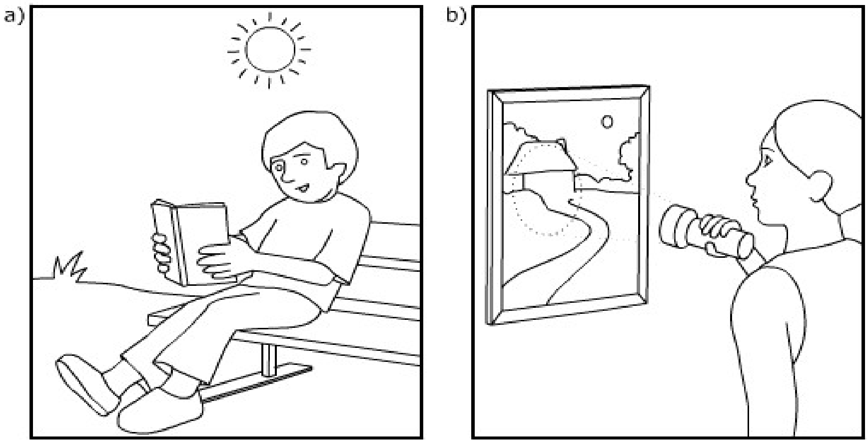
____

Activity 6 How we see things (3)

Draw arrows (representing light) on the pictures below to show how:

6.1 The boy can see the page of the book he is reading.

6.2 The girl can see the picture on the wall.



Activity 7

What happens when light hits something?
Complete the activity below by solving for the missing letters and then answer the question below the puzzle.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
10				4	11			15				23		26								9			

W _ E _   _ I _ _ _   _ I _ _   A _   O _ _ E _ _ ,
9 3 4 24   8 15 18 3 7   3 15 7 2   10 24   26 22 21 4 20 7

_ I F F E _ E _ _   _ _ I _ _ _   _ A _   _ A _ _ E _
16 15 11 11 4 6 4 24 7   7 3 15 24 18 2   20 10 24   3 10 17 17 4 24

_ O   I _   _ E _ E _ _ I _ _   O _   W _ A _   _ _ E
7 26   15 7   16 4 17 4 24 16 15 24 18   26 24   9 3 10 7   7 3 4

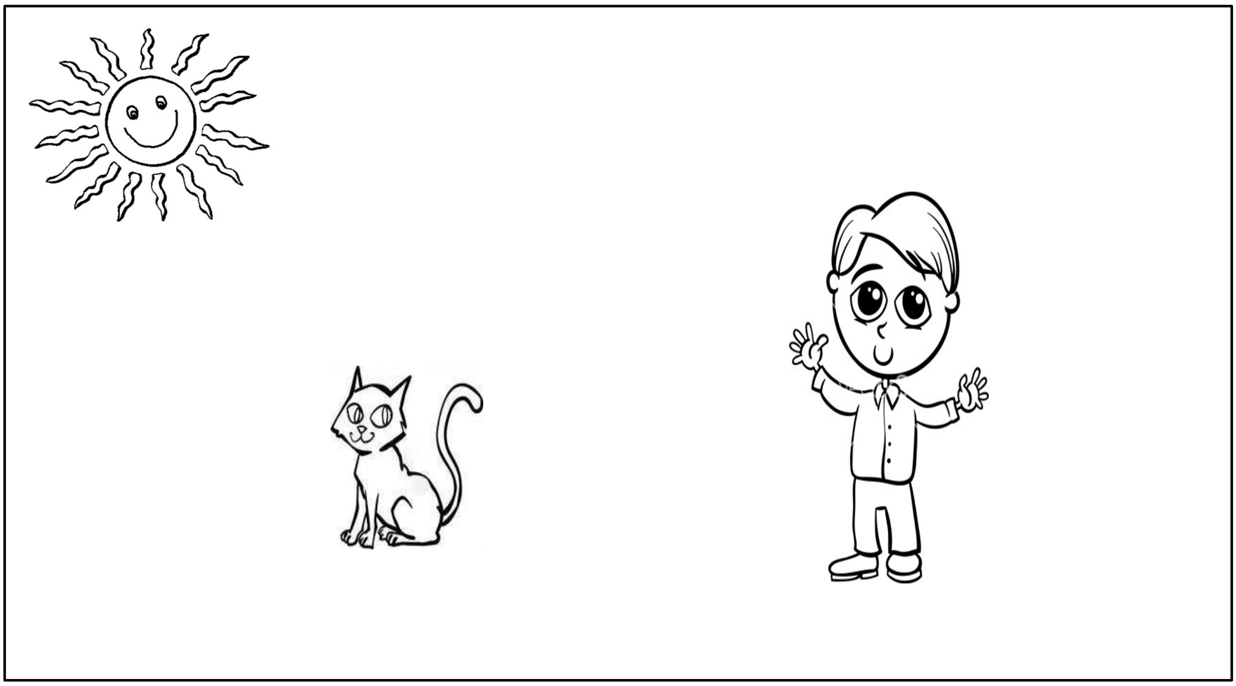
O _ _ E _ _   I _   M A _ E   O _ _   O F .
26 22 21 4 20 7   15 2   23 10 16 4   26 1 7   26 11

Make a list of the things that light can do. These are the first letters.

T_________
A_________
R_________
B_________

Activity 8

8.1 Add light rays to the picture below, showing how the boy sees white cat.



8.2 Draw in the shadows of the cat and boy.

8.3 Write a few sentences to explain what is going on. In your explanation use the following key words:

Opaque, Light, Sun, Luminous, Shadow.

____

____

____

____

____

____

____

____

____

Pinhole Camera Template