The effects of a lesson study intervention on the teaching of electricity and magnetism.

by

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Philosophiae Doctor

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Declaration

I **Ayodele Abosede Ogegbo** with student number 15310142 hereby declare that this thesis submitted for the degree Doctor of Philosophy at the University of Pretoria, South Africa, is my own original work and has not been submitted for any degree or examination at any other institution of higher education. I further declare that all sources cited or quoted in this study are indicated and acknowledged by means of a comprehensive list of references. Moreover all research procedures stated in this thesis received approval from the University of Pretoria ethics committee.

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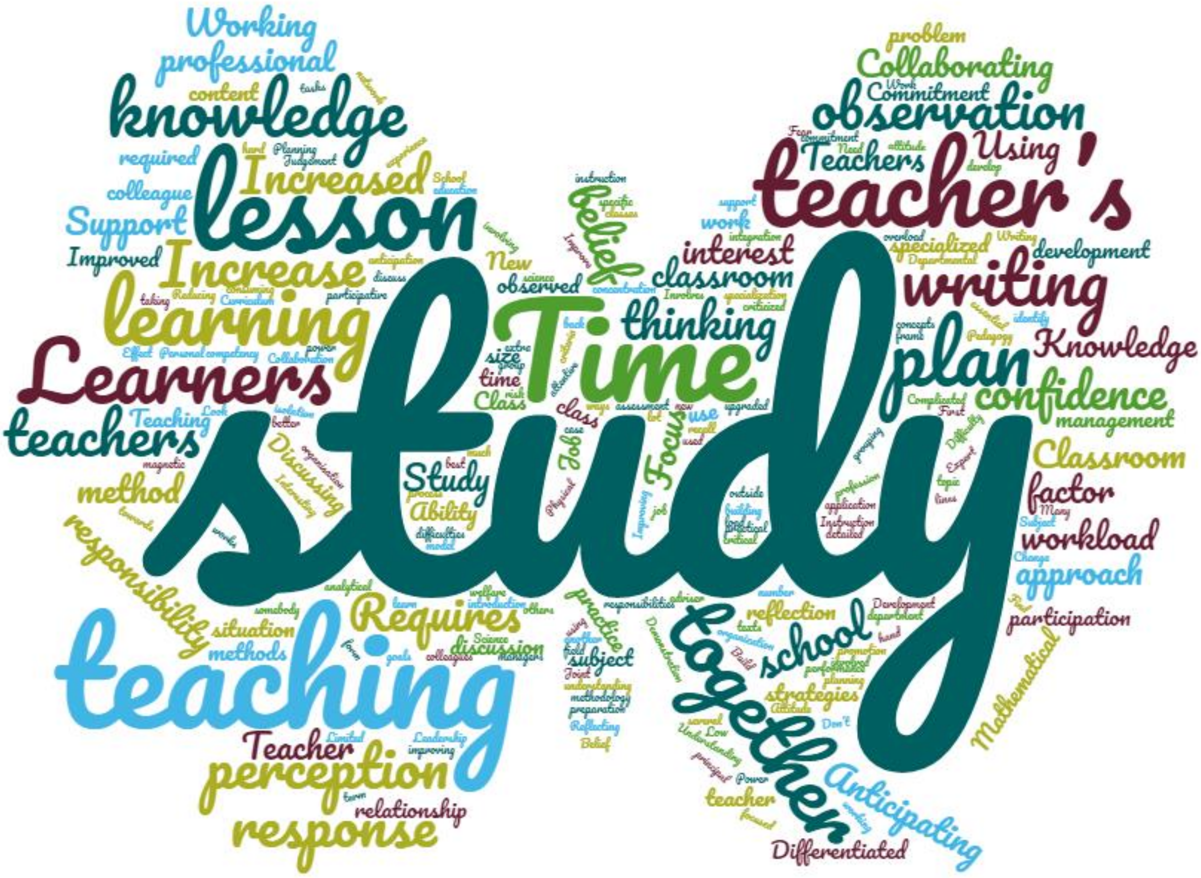
- Data storage requirements.

Ethics Statement

The highest ethical standards were maintained in this thesis. The ethical consideration for this study are discussed in detail in Section 3.8.

Dedication

I dedicate this research to the Almighty God who has stood by me and brought me this far in the journey of life. His grace has been and will continue to be sufficient for me.



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Abstract

An in-depth case study was undertaken with the purpose of exploring teachers use of Lesson Study as they progressively strive to enhance their teaching of electricity and magnetism. A sample of four physical sciences teachers functioning separately as two lesson study pairs was conveniently selected from three different schools. Data were obtained through semi-structured interviews, individual teacher's lesson observation and Lesson Study pair observation, field notes, document analysis of participants' reflective writing and original lesson plan. The social constructivist learning approach of Vygotsky and the adult education approach of Malcolm Knowles was used as the theoretical framework of this study. Data obtained was analysed using qualitative content analysis.

Results from this study indicates that individual interpretation of personal experiences and active collaboration with colleagues during Lesson Study meetings changed participants' attitudes, beliefs and practices about teaching electricity and magnetism. Participants became more confident and competent teaching specific concepts in electricity and magnetism after the brainstorming sessions of the Lesson Study process. However, participants identified lack of support, unavailability of time and workload as contextual factors that might affect their continuous practice of the Lesson Study process.

This study provides insight to how and why physical sciences teachers should collaboratively learn within the context of Lesson Study. It also contributes to the knowledge about how to promote effective and practical school based collaborative professional development programs among teachers. It is recommended that educational policy makers should develop strategic plans that allow teachers to engage in practical and effective collaborative professional development programs such as Lesson Study during the school day. Furthermore, the practice of collaborative teaching should start in teacher training programs to help reduce professional isolation among teachers.

Key Words: Lesson Study, Physical sciences, Teachers' Professional Development, Electricity and Magnetism.

Language Editor's disclaimer

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TO WHOM IT MAY CONCERN

This is to confirm that the thesis titled ***"THE EFFECTS OF A LESSON STUDY INTERVENTION ON THE TEACHING OF ELECTRCITY AND MAGNETISM"*** by Ayodele Abosede Ogegbo was proof read and edited by me in respect of language.

I verify that it is ready for publication and / or public viewing in respect of language and style.

Please note that no view is expressed in respect of the subject specific technical contents of the document or changes made after the date of this letter.

Kind regards

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List of abbreviations

AAAS	American Association for the Advancement of Science
AAEE	Association for Employment in Education
AAPT	American Association of Physics Teachers
ACE	Advance Certificate in Education
AIP	American Institute of Physics
APS	Association of Psychological Science
BEMA	Basic Electricity and Magnetism Assessment
CDE	Centre for Development and Enterprise
CUE-CMR	Colorado Upper-Division Electrostatic Diagnostic – Coupled Multiple Response
CUE-FR	Colorado Upper-Division Electrostatic Diagnostic Free Response
CSEM	Conceptual Survey of Electricity and Magnetism
CK	Content knowledge
CPS	Continuous Professional Development
CAPS	Curriculum Assessment and Policy Statement
CCTEM	Czech Conceptual Test from the area of Electricity and Magnetism
DBE	Department of Basic Education
DoE	Department of Education
DIRECT	Determining and Interpreting Resistive Electric Circuit Concepts Test
ECCE	Electric Circuits Conceptual Evaluation
EMCA	Electricity and Magnetism Conceptual Assessment
EMCI	Electromagnetics Concept Inventory
FET	Further Education and Training
GPK	General Pedagogical Knowledge
IKS	Indigenous Knowledge Systems
IBCDC	Inventory of Basic Conceptions – DC Circuits
ISPFTED	Integrated Strategic Planning Framework for Teacher Education and Development
JICA	Japan International Cooperation Agency

MCS	Magnetism Conceptual Surveys
METP	Measures of Effective Teaching Project
MSSI	Mpumalanga Secondary School Initiative
NIPTE	National Institute for Physics Teacher Educators
NPC	National Planning Commission.
NIPTE	National Institute for Physics Teacher Educators
NSMSTE	National Strategy for Mathematics, Science and Technology Education
NCLB	No Child Left Behind
OECD	Organisation for Economic Co-operation and Development
PCK	Pedagogical content knowledge
PGCE	Postgraduate Certificate in Education
PhysTEC	Physics Teacher Education Coalition
PEA	Provincial Education Authority
SACE	South African Council for Educators
TALIS	Teaching and Learning International Survey
TIMMS	Trends in Mathematics and Science Study
UNESCO	United Nations Educational Scientific and Cultural Organization
WEF	World Economic Forum
ZPD	Zone of proximal development

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1. CHAPTER 1: INTRODUCTION AND CONTEXTUALISATION

1.1 Introduction

This study explored teachers' views and behaviours towards the teaching of electricity and magnetism during a Lesson Study intervention. A case study involving four physical sciences teachers was undertaken to gain an in-depth understanding of the process of change in teachers' knowledge and classroom practice in this Lesson Study intervention. Factors that affect teachers' effective participation in Lesson Study were also investigated.

Several research-based professional teacher development models, such as action research, mentoring and cluster work have been reported to support various aspects of teachers' knowledge and classroom practice (Jita & Mokhele, 2014; Mapotse, 2012; Owusu-Mensah, 2014; Ramnarain & Ramaila, 2012). The introduction of action research practices to the education sector has helped teachers to be more effective about their teaching practice and learners' performance (Lesha, 2014). Action research involves cycles of activities aimed at improving teachers reflective practice, professional cultures and making progress on school academic priorities (Lesha, 2014). Another professional model that involves cycles of inquiry activities targeted at improving instruction is Lesson Study, which has been used with great success to improve teachers' practices and learners' learning (Fernandez, 2002; Ono & Ferreira, 2010). Lesson Study could be described as a form of classroom based action research practice that uses the different phases of planning, teaching, observation and reflection. Several studies have been carried out on ways of implementing Lesson Study as a professional development design for teachers of mathematics (Coe, Carl & Frick 2010; Ono & Ferreira, 2010; Stols & Ono, 2016) and the nature of its reflective practice on improving the pedagogical content knowledge of mathematics teachers in South Africa (Posthuma, 2012). However, none to date have focused on how physical sciences teachers use the Lesson Study process to enhance their professional competence. This study, therefore, contributes to the body of knowledge by exploring how physical sciences teachers use the Lesson Study process to teach electricity and magnetism.

1.2 Background of the study

Education and science are regarded as the key driver of a nation's progress, regeneration, and future prosperity, especially in areas of the labour market, innovation, trade and human capital development (United Nations Educational, Scientific and Cultural Organization (UNESCO, 2017). This implies that the key to building the economy and future prosperity of any country is producing professionally qualified candidates suitable for the country's workforce through quality science education (National Planning Commission (NPC), 2013). One of the fundamental purposes of science education in the 21st century is preparing learners to acquire and apply the scientific knowledge and skills required to thrive in today's world. Sciences provide useful preparation for learners who plan to take up science-oriented careers and it introduces basic physics concepts such as electricity, magnetism, motion, force and energy.

Physics has played a fundamental role in the development of almost all other disciplines in science and every kind of technology makes use of the scientific principles linked with physics. Despite the importance of physics, studies have revealed that there are factors affecting the performance and enrolment of learners in physics (Ernest, 1989; Marusic & Slisko, 2012; Ornek, Robinson & Haugan, 2007; Saglam & Millar, 2006). For instance, the American Association of Physics Teachers (AAPT, 2013) indicates that learners' performance and enrolment in physics have been reflecting a decline over many years probably due to the abstract nature of the subject. Marusic and Slisko (2012) claim that learners consider the subject to be too mathematicallly oriented, too extensive and mostly dependent on textbooks. Research indicates that most learners do not enrol for physics at the university level because very few learners offer physics at the secondary school and the best of them end up enrolling for courses like medicine, engineering and other lucrative courses at the tertiary institution. This makes it difficult to find skilful university graduates to become physics teachers (Mbamara & Eya, 2015). According to Masood (2014), the decrease in physics performance and enrolment is one of the biggest challenges for physics in the 21st century since most learners lack motivation. Research claims that the poor performance and low enrolment of physics in the United State can be attributed to the social and cultural basis of the nation, where most of the learners perceive physics as a difficult subject that requires extra time and hard work in understanding the subject

(Masood, 2014). Osborne, Simon, and Collins (2003) explain that the poor performance and low enrolment of learners in physics oriented courses could be attributed to the negative attitude learners develop towards physics.

There are several historical, systematic, social, school, political, environmental and individual factors that have contributed in a complex way to the downward trend of learners' enrolment and poor performance in physics (Ernest, 1989; Hampden-Thompson, Lubben & Bennett, 2011; Ornek et al., 2007; Tesfaye & White, 2012). One of the identified factors contributing to this trend is related to physics teachers' professionalism in terms of knowledge, skills, attitudes, beliefs and classroom practice (Blömeke & Delaney, 2012; Medley, 1977; Mji & Makgato, 2006; Shulman, 1987). It is possible that most teachers still use the one-way traditional teaching method as a classroom practice in teaching physics. In fact, the AAPT (2013) claim that the traditional one–way lecturing approach of teaching high school physics is ineffective since it does not support learners to comprehensively and correctly understand basic scientific concepts. Learners could develop inadequate understanding from such teaching practice, which may later develop into misconceptions and may to some extent affect their performance in the subject.

Learners' performance in terms of results depends on many factors within and outside the school. Most important is the teacher-related factor. According to Mudasir and Ganai (2017), there is an asserted saying that "No educational organization can develop above the standard of its teachers". This implies that without a knowledgeable, strongly inspired and proficient teacher, the link to educational accomplishment in learners' academic performance will gradually collapse. The 2001 No Child Left Behind (NCLB) act in the United States indicates that proper preparation of teachers should include teachers' ability to understand the knowledge of teaching and learning, being knowledgeable about the subject matter, having prior experience and the necessary set of qualifications as required by the teaching governing body, and having these indicators as some of the requirements that determines teachers' effectiveness (US DoE NCLB Act, 2001). According to a survey carried out on measures of effective teaching in the United States by the Bill and Melinda Gates Foundation, report indicate that effective teachers are the principal factor contributing to learners' success and they are therefore termed as the keystone of quality in any education system (Kane, Kerr & Pianta, 2014).

Since physics education is a major factor in enhancing the drastic technological revolution required to meet the needs of any country, the skills provided in the 21st-century education must be aligned with this technological transformation. This requires the teaching and learning of physics to be characterized by an interactive and experimental practice, where learners are active in studying new knowledge under the guidance of a teacher. However, research indicates that teachers encounter a variety of problems which are unique to the teaching of physics (Tesfaye & White, 2012). This implies that teachers need to engage in professional development that will enhance their teaching strategies. The development of new teaching strategies helps to promote active learning in physics rather than using the traditional method of teaching which has made the learning of physics passive (Maftei & Popescu, 2012).

1.3 Context of the study

Physical sciences is offered as a subject combination of physics and chemistry in South Africa, and it is one of the prioritized subjects at the Further Education and Training (FET) level. Physical sciences serves as a foundation upon which many scientific innovations and modern technologies that citizens take for granted are built upon (DoE, 2003). The study of physical sciences as stated in the Curriculum and Assessment Policy Statement document (CAPS) aims to improve learners' understanding of how scientific knowledge, technological knowledge, and indigenous knowledge systems work in their physical environment (DoE, 2003). As economic development is being enhanced by innovations rooted in the application of physics, the effective teaching of physical sciences becomes very important to meet the technological needs of South Africa.

Research indicates that South Africa has a footprint in which the standard of teaching physical sciences at the secondary school level is poor due to teachers' insufficient knowledge about the content of the subject and the poor method of teaching the subject (Reddy, Prinsloo, Arends, Visser, Winnaar, Feza & Ngema, 2013). It is possible that teachers' insufficient knowledge of subject matter could be responsible for learners' low academic achievement in physical sciences at matriculation examinations. The poor performance of science learners in South Africa is evident in international studies such as the Trends in Mathematics and Science Study (TIMSS). Reports on TIMSS (2011) reveal that learners in South Africa still lag behind learners in other nations, particularly Asia, America and European countries (Reddy et al., 2013). According to the 2012/2013 global competitiveness report by World Economic Forum (WEF), South Africa was positioned 140 out of 144 countries in its overall quality of education; and 143 out of 144 for mathematics and science education (Schwab, Sala-i-Martín & Brende, 2012). In a survey conducted within 62 countries (which included Bangladesh, Kenya, Tanzania, and Colombia) in order to determine the quality of science and mathematics Education rendered in schools, South Africa was placed last (Schwab et al., 2012). This implies that South Africa still has a low average performance in physical sciences as compared to other countries (Reddy et al., 2013).

The poor performance of learners in physical sciences is also evident in the National Senior Certificate examination results which reflect low academic achievement attained in the subject. Table 1.1 shows a comparison of South African learners' performance in physical sciences at the final Grade 12 matriculation examination over nine consecutive years.

Table 1-1: General achievement rate of physical sciences learners from 2008 to 2016.

Year	Total figure of learners who wrote physical sciences	Total figure of learners that attained 30% and above	% attained at 30% and above	Total figure of learners that attained 40% and above	% attained at 40% and above
2008	217 300	119 206	54.9	62 530	28.8
2009	220 882	81 356	36.8	45 452	20.6
2010	205 364	98 260	47.8	60 917	29.7
2011	180 585	96 441	53.4	61 109	33.8
2012	179 194	109 918	61.3	70 076	39.1
2013	184 383	124 206	67.4	78 677	42.7
2014	167 997	103 348	61.5	62 032	36.9
2015	193 189	113 121	58.6	69 699	36.1
2016	192 618	119 427	62.0	76 044	39.5

Source: National Senior Certificate Examination Report, Department of Basic Education (2016).

Table 1-1 shows that learners' enrolment in the subject has been experiencing an overall decline since 2008. Though the pass rate of learners increased over the years, the academic achievement of learners in terms of quality across the country remains low. The quantity of learners that passed is determined by the number of learners who achieved 30% and above while the quality of performance is determined by the number of learners who achieved 40% and above. The low performance of learners is visible in the fact that typically less than 40% of learners are achieving above 40%. The poor academic achievement in physical sciences indicates a low number of suitably skilled and qualified secondary school physical sciences graduates produced by the education system. This ultimately implies that the number of people with critical, analytical, problem-solving and technical skills that will enrol for science-oriented careers at the university level and eventually join the South African science community is inadequate. This is a serious concern for the country because it inhibits the growth of the South African economy.

To improve learners' academic achievement in physical sciences, Selvaratnam (2011) suggested that the physical sciences curriculum should be targeted to train learners on how to use their acquired scientific skills to solve environmental problems. These skills include the ability to classify, communicate, measure, design investigations, draw and evaluate conclusions, formulate models, state hypotheses, identify and control variables, infer, observe and compare, interpret, predict, offer solutions to problems and reflect on results (DBE, 2011). However, despite the characteristics attributed to physical sciences as a subject that encourages a responsible and ethical attitude towards learning, the use of scientific methods which creates an opportunity for reflection and discussions on fundamental theories is not practiced by some physical sciences teachers (DBE, 2014).

Physical sciences education in secondary school is facing countless issues. For instance, research in South Africa indicates that there is not adequate time available to implement all aspects of physical sciences required by the curriculum. Studies claim that teachers teach only examined content since the curriculum is overloaded (Basson & Kriek, 2012; Ramnarain & Fortus, 2013). This could possibly mean that not enough time is allocated for teachers to cover the required physical sciences content in class.

This is one of the major challenges that could contribute to the low academic attainment of physical sciences learners in the country. Other issues facing physical sciences education in South Africa includes lack of school safety and infrastructure, beliefs and attitudes towards science education, inadequate availability of resources, poorly equipped laboratories, frequent change in the curriculum, school leadership, parental background, poorly trained teachers, the negative attitude of learners towards physical sciences, the difference between the language of instruction and language at home (Cho, Scherman & Gaigher, 2012; Hampden-Thompson et al., 2011; Mji & Makgato, 2006; Reddy et al., 2013). Furthermore, research indicates that new topics in the revised South African curricula have always been teacher-centred with little provision for learner classroom activities due to teachers' poor understanding of the topic (Ramnarain & Fortus, 2013). These are some of the challenges facing physical sciences education in South Africa. This implies that there is an urgent need for research on how to enhance the knowledge base of physical science teachers, in order to achieve better learners' outcomes.

1.4 Rationale for the study

In my own experience as a physics instructor from Nigeria and an assistant examiner of physics in the West African Examination Council for four years, I observed that many physics teachers and learners find it difficult to understand concepts associated with electricity and magnetism. This was evident in their inability to satisfactorily interpret and answer questions on the topic correctly. This experience motivated me to want to understand the factors that influence this result. After relocating to South Africa, I found that this trend was similar in South Africa (DBE, 2014, p.142; Hekkenberg, Lemmer, & Dekkers, 2015).

Electricity and Magnetism (which includes electromagnetism) together form one of the core knowledge areas in the FET physical sciences curriculum in South Africa (DBE, 2011; Hekkenberg et al., 2015). It comprises 36.6 % of the final physical sciences matriculation examination (DBE, 2011, p.150). According to Saglam and Millar (2006), learners develop a negative perception of this knowledge area of physical sciences because they view it as an abstract topic and find it difficult to comprehend. This together with other factors such as physical sciences teachers' classroom practice, for example, are some of the factors that may contribute to the poor results in South

African physical sciences. It is this factor in particular which is of interest. The nature and origin of learners' conceptual difficulties in electricity and magnetism may to some extent depend on teachers' inability to effectively teach concepts associated with this topic (Hekkenberg et al., 2015; Ramnarian & Fortus, 2013; Reddy et al., 2013). This, in turn, can be attributed to:

- Teachers' lack of relevant content and pedagogical content knowledge on electromagnetism (Saglam & Millar, 2006),
- Teachers' lack of confidence in teaching the topic (Mensah, 2014),
- Teachers' inadequate use of inquiry approaches for teaching (Adeyemo, 2010),
- Teachers' use of traditional teaching methods and strategies such as only lecturing on content (Marusic & Slisko, 2014).

To address these challenges, teachers should be exposed to research based strategies that can enhance their knowledge base and instructional skills in all aspects of teaching physical sciences. One probable means of enhancing the knowledge base of teachers is through a collaborative professional development called Lesson Study, since lesson study has shown to be one of the effective models used in improving mathematics teachers' practices (Fernandez, 2002; Lewis& Hurd, 2011). The introduction of Lesson Study as a personal growth model for professional teachers has been used with much success in the education system in countries like Japan, America and other parts of Asia (Lewis & Hurd, 2011; Pang & Ling, 2012; Stols & Ono, 2016). Noffke (1997) described Lesson Study as a framework for constructing and sharing professional knowledge which involves teachers learning from teammates as they research, plan, teach, observe and discuss a research lesson together. In Lesson Study, teachers aspire to develop their knowledge by participating in group discussions. This helps them to gather information and develop capacity building strategies that will support the improvement of instructions and teaching goals. Research indicates that the Lesson Study model emphasises more on learners' interest rather than teachers' knowledge (Noffke, 1997; Pang & Ling, 2012).

Studies have shown that Lesson Study has been used as a professional training model to enhance the teaching and professional practice of mathematics teachers (Fernandez, 2002; Lewis & Hurd, 2011; Pang & Ling, 2012). Lesson Study has also been used to improve the reflective practice of mathematics teachers in South Africa

(Posthuma, 2012). Posthuma (2012) claims that the successful adaptation of Lesson Study as a professional model will help teachers when they are among other colleagues to reflect personally upon their teaching method and develop ways of improving such methods. Stols and Ono (2016) claim that mathematics teachers in South Africa can use Lesson Study as a bottom-up professional development approach to learn more about their learners and improve their classroom practices. Regardless of all that has been discussed**,** no studies on how physical sciences teachers use the Lesson Study process to teach electricity and magnetism could be found. The present situation in the education system of South Africa concerning learners' performance in physical sciences demands an urgent need to conduct research that may lead to improved learners' performance. It is important for teachers to work together to identify and address learners' difficulties in physical sciences. Since Lesson Study has successfully promoted the instructional development of Japanese teachers through collaborative instructional research (Ono & Ferreira, 2010), it is, therefore, the intention to investigate how a Lesson Study intervention influence the process of change in physical sciences teachers' knowledge and classroom practice within the topics of electricity and magnetism in the South African context.

It is possible that participation in Lesson Study may give physical sciences teachers the opportunity to develop modern teaching strategies rather than using the traditional method of teaching which has made teaching and learning of physics passive (Maftei & Popescu, 2012; Marusic & Slisko, 2014). The use of Lesson Study as a school-based professional development model may help physical sciences teachers to collectively acquire knowledge from an individual's experiences, and improve their pedagogical content knowledge in teaching electricity and magnetism. This could possibly improve learners' performance and academic achievement in physical sciences. This Lesson Study intervention may also improve learners' reading, problem-solving, scientific thinking and writing skills. However, for this study, learners' performance will not be used as a measure to assess this Lesson Study intervention as the focus is on physical sciences teachers. By means of participating in this study, teachers can ultimately:

- Adopt this collaborative learning and reflective practice in all their teaching,

- Develop their learners’ cognitive and problem-solving skills, and
- Enhance their learners’ performance in physical sciences.

1.5 Statement of purpose

The objective of this research study was to (1) understand how the Lesson Study process enhances physical sciences teachers’ knowledge, skills and classroom practices ,(2) understand participants’ views and behaviour towards the teaching of electricity and magnetism during Lesson Study intervention, (3) explore teachers’ perception of factors affecting their participation in professional development programmes. To achieve this aim, an in-depth exploration of physical Science teachers’ knowledge of teaching electricity and magnetism was conducted before the Lesson Study intervention. Furthermore, teachers’ experiences while participating in the Lesson Study intervention were investigated. Factors affecting teachers’ participation in the Lesson Study intervention were also investigated.

1.6 Research question

Main question: How does the Lesson Study process support the teaching of electricity and magnetism?

This main question will be addressed by the following sub-questions:

- How does Lesson Study influence teachers’ knowledge about teaching electricity and magnetism?
- How does Lesson Study influence teachers’ attitudes and beliefs towards teaching electricity and magnetism?
- What are the contextual factors affecting teachers’ participation in the Lesson Study process?

The researcher chose to avoid explicit reference to the construct of pedagogical content knowledge (PCK) in the research question due to the complexity and debate about the nature of PCK (Gess-Newsome, 2015; Magnusson, Krajcik & Borko, 1999; Shulman, 1987; Tamir, 1988; Van Driel, Verloop & De Vos 1998). PCK is a complex construct that may obscure the focus of the study.

1.7 Methodological considerations

My study aimed to understand how physical sciences teachers use the Lesson Study process to practically plan, teach, observe, discuss and reflect on teaching electricity and magnetism. Such in-depth understanding requires the use of a qualitative approach which is based on the epistemological viewpoint of the interpretive paradigm. It is a case study design of teachers' action research practice.

1.8 Possible contribution of this research study

The knowledge of physical sciences in this era is closely linked with technological advancement and innovative practices. This requires developing teachers by building professional learning communities so that they can share their commitment to learners' development and prepare learners for assessment tasks meeting international standards. More so, the physical sciences research community is seeking for ways to make physics education more accessible and interesting. The use of Lesson Study has been documented in the local and international literature as an effective professional development model for improving mathematics teachers' classroom practice. However, physical sciences teachers in South Africa may not be able to decide if the use of Lesson Study as a professional development model in physics classrooms is effective or not. This study sought to clarify the issue.

The uniqueness of this study is within the South African context, where two pairs of physical sciences teachers were engaged in the Lesson Study process as a school-based professional development mode of inquiry. During the research, they collaborated, taught, observed, and reflected on their teaching of electricity and magnetism. It is envisaged that teachers would use this professional experience to improve their pedagogical practice and content knowledge. This may improve learners' conceptual understanding of the topic as well as their problem-solving skills. The study can add to research findings and discussions on the usefulness of Lesson Study as an action research practice among physical sciences teachers. Furthermore, this research may provide useful information that will inform policy on Lesson Study as a professional training strategy that enhances the meaningful teaching of physical sciences across South African classrooms rather than using mostly the traditional teaching methods .

1.9 Structure of thesis

The structure of this thesis is briefly outlined below:

Chapter 1

Chapter 1 introduces the study, providing the relevant background, context, rationale, aim and research questions. The methodological considerations, possible contributions, and limitations to the study are briefly mentioned.

Chapter 2

This chapter gives an in-depth discussion of literature about teachers' and learners' difficulties in electricity and magnetism, and how Lesson Study may be used as a professional training model for improving physical science teachers' practice particularly in teaching these topics. It also describes the theoretical framework underlying the investigation.

Chapter 3

This chapter firstly describes the philosophical foundation of the study. It also explains how the research was conducted in terms of the research design, data collection techniques, and data analysis strategies. Quality assurance criteria and ethical considerations are also discussed.

Chapters 4 and 5

The data obtained from the two Lesson Study pairs are presented separately in these two chapters. Chapter 4 will discuss data obtained from Lesson Study Pair A and chapter 5 will discuss data obtained from Lesson Study Pair B.

Chapter 6

This chapter presents the conclusions and discussions of the findings related to the research questions, the researcher's reflection, limitations of the study, contributions of the study, implications, and recommendations for future research.

1.10 Chapter summary

In this chapter, the study is introduced by the discussion of major problems facing physical sciences learners and teachers worldwide and in South Africa. Findings from the literature that discussed the success of Lesson Study as a professional training model centred on learners' academic interest and teachers' professional growth, and formulated aim of research questions were outlined. The next chapter presents the literature that was reviewed for this study.

2. CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

In this chapter, significant literature related to this research study is reviewed. The literature reviewed presents a discussion on the nature of physical sciences as a subject, the importance of electricity and magnetism in the science curriculum, professional training of physical science teachers, and the use of Lesson Study as a practical model of teachers' professional growth. The theoretical framework that underpins the practice of Lesson Study as a school-based professional training program is discussed. This section concludes with a conceptual structure of the study, which rests on the amalgamation of concepts and assumptions reviewed in the literature.

2.2 The nature of physical sciences as a subject.

It is important to know that South Africa is a country that offers Physical sciences as a subject combination of chemistry and physics to learners from Grades 10 to 12. Grayson, McKenzie, Dilraj, Harris, Burger, and Schreuder (2005) describes physical sciences as a field of study that scientifically investigates the components, structure, and properties of matter and their interaction with non-living things in our environment. Moreover, physical sciences investigates chemical and physical processes that occur in life by using scientific theories to predict, explain and understand the world around us (DBE, 2011). The concept of physical sciences deals with the behaviour of matter and energy, which explains natural phenomena in the universe; which are in relation with other physical properties such as weight, mass, volume and other standard objective measures. Physical sciences is an essential science subject, which underlies the economic development of most professions in the society because it is a vital ingredient in the invention of most modern technology (Taale, 2011). The current physical sciences curriculum for South African learners in grades 10, 11 and 12 offers physics and chemistry as a combined subject in the Curriculum and Assessment Policy Statement document (CAPS). The physical sciences curriculum is structured to develop learners' scientific and critical thinking skills, and strengthen learners' interest for future scientific reasoning and research (DBE, 2011). These skills include inquiry processes such as "classification, communication, measurement, designing and investigation, drawing and evaluating conclusions, model's formulation, hypothesis formulation, identification and controlling of variables, predicting, acquisitive, inferring, manipulative, problem solving, interpretation, reflective, observing, organizational and comparing skills" (DBE 2011, p.8). In this regard, Physical sciences provide answers to questions on philosophical issues about the nature of the universe and provide alternative solutions to technological problems. Unfortunately, learners' performance in physical sciences still remains poor and this is causing the population of learners with a basic understanding of scientific concepts to diminish.

Physical Science is significant to the advancement of a nation through science and technology; however, learners believe that the content of physical Science as a subject especially physics is abstract in nature and this makes it difficult for them to understand the subject (Marusic & Slisko, 2012). Due to the abstract nature of physics, Lederman and Abd-El-Khalick (1998) argued that physics instruction should be explored using research-based strategies alongside laboratory exercises aimed at validating ideas and lessons taught in the classroom. Unfortunately, many teachers use the one-way traditional lecture method and ignore the practical aspect of the subject. The American Association of Physics Teachers claimed that physical science lessons are better understood when classes are complemented with hands-on experiments and tasks that need learners to collaboratively review what happens in such experiments and why (AAPT, 2013). However, the strategies employed in teaching physical sciences have changed over time due to technological advancement (Nelson, 2006). Nelson described these changes as an evolutionary framework characterised by the emergence of traditional textbooks in the first generation, the use of inquiry-based materials in the second generation, the incorporation of cognitive research-based materials in the third generation and emerging research on teachers' collaborative learning in the 21st century. It is possible that understanding the process of change in instructional materials from each generation could provide teachers with opportunities to improve their professional knowledge, teaching strategies and learners' conceptual understanding of physical sciences.

According to Adeyemo (2011), physics and some branches of mathematics have been part of a natural philosophy that have made significant contributions to the modern society through success in innovations arising from conceptual headways over the last decades. Olufunke (2012) believes that physical sciences links mathematical knowledge to real-life applications and allows learners to grasp ways of solving problems in a more coherent and practical way thereby gaining new recognition and value for the world around them. In this regard, physical sciences as a subject uses mathematical concepts and operations in its laws and calculations. It is a general belief that mathematics is the language for physical scientists especially the physicists and this means that without proper mathematical knowledge it is impossible to understand or learn higher physical science courses.

Reports from the 2011 Physics Teacher Education Coalition (Phys TEC) Conference indicate that many countries require that Physical sciences especially Physics be made compulsory for all secondary school learners (Meltzer & Shaffer, 2011). Physical sciences education is facing a major setback globally due to the poor performance and recorded decrease in the number of learners enrolling for physics at both secondary and tertiary institutions (Kola, 2013; Osborne, Driver & Simon,1998; PhysTEC, 2011). In South Africa, learners' enrolment in physical sciences vary year to year and learners performance in the subject remains low (DBE, 2015). However, research indicate that learners' interests and attitude play a significant role in studying physical sciences (Erdemir, 2009). This implies that the poor performance of learners in physical sciences could be attributed to their negative attitude towards the subject.

2.2.1 Attitude of learners towards physical sciences

Attitude is the mental position of readiness in an individual, premeditated through daily experiences thereby influencing how we respond to a related stimulus (Bhargava & Pathy, 2014). Attitude is an essential disposition that directs the nature of human behaviour and relates to how individuals manage emotions that occur during the learning process. Attitude as used in this study refers to emotional dispositions that include constructs like conceptions and behaviours of teachers towards teaching physical science as a subject. The American Association for the Advancement of Science (AAAS) emphasised the urgent need of improving learners' attitude towards courses related to physical sciences as a major reform in science education. The AAAS (2010) claims that developing a negative attitude towards physical sciences will lead to learners' lack of concentration especially in cases where the learners have options of offering other courses instead of physical sciences. More so, developing a positive attitude could enhance learners' interest and commitment to studying the subject.

Researchers in the science education community have pointed out several elements that could be responsible for negative attitude teachers and learners develop towards studying physical sciences. Some of these factors include poor mathematical skills, content of traditional physics curricula, teachers' and learners' negative perception of Physics as a subject and lower enrolment rates of girls in a physics classroom (Adeyemo, 2011; Ernest, 1989; Marusic & Slisko, 2012; Ornek et al., 2007). The number of learners who desire to study physical sciences and its related career courses at the university level is continuously declining (Movahedzadeh, 2011). This negative trend results from the negative attitude that learners develop towards the subject. Such negative attitudes include learners' undesirable experience in previous science classes, unpleasant experiences and perceptions of previous science teachers, lack of enthusiasm towards working hard in science classes, fear of failure on the subject and lack of self-confidence, inability to learn and apply scientific concepts due to lack of required skills, the nature of school and classroom environments, attitude of teachers and peer groups towards physical sciences as a subject (Ernest, 1989; Movahedzadeh, 2011; Ornek et al., 2007).

In a study carried out in the KwaZulu-Natal province on factors contributing to poor learner performance in physical sciences, Dhurumraj (2013) indicated that the learning of physical sciences is more difficult for African learners who attend English medium schools and speak English as a second language. Most South African parents lack English proficiency due to the legacy created by segregation and differentiated schooling systems (Dhurumraj, 2013) and this makes them (learners) develop a negative attitude towards physical sciences oriented tasks. Olusola and Rotimi (2012) believes that the attitude of most learners on decisions to choose physical sciences or not depends on the characteristics of the learner in terms of academic abilities, family background, and the value physical sciences is considered to have in a certain career in the country in which the learner resides. More so, learners consider physics as a subject that is too extensive, too mathematically oriented, too abstract in nature and greatly dependent on textbooks (Marusic & Slisko, 2012); this creates a negative attitude in learners thereby resulting in lower enrolment rate and poor academic performance in physical sciences at final examinations (Adeyemo, 2011). Moreover, the negative attitudes of learners towards learning are one of the factors causing difficulties among learners (Olusola & Rotimi, 2012).

It is possible that teachers focus on ways of strengthening learners' understanding of specific topics rather than helping them build favorable attitudes toward the subject. Kormur and Eryilmaz (2012) suggested that teacher characteristics such as teachers' age, the method of classroom evaluation, gender, general attitudes, experience, and specific attitudes towards learners when teaching are some of the factors that affect learners' achievement and attitude towards physical sciences. Olusola and Rotimi (2012) indicated that learners' attitude towards physical sciences can be changed based on the level of learners' exposure to science, the teaching method, and the learning environment. Research claims that the attitude developed towards studying Physical sciences is determined by learners' interest, personal effectiveness, motivation, self-concept in physical sciences, achievements, learners' preparation towards studying the subject and teachers training on how to innovate and implement new strategies in teaching physical sciences (Adeyemo, 2011; Marusic & Slisko, 2012). However, it seems that learners gain positive attitudes toward physical sciences as they learn more but unfortunately, some learners tend to have negative attitudes towards physical sciences due to the assumed difficulty and misconceptions created in some theoretical perspective of the subject (Erdemir, 2009; Karenauskaitė & Jucevičienė, 2005).

2.3 Overview of electricity and magnetism as a concept in the science curriculum

Electricity and magnetism is a fundamental knowledge area in sciences that cuts across the primary, secondary and tertiary education in any country. The most significant aspect of this knowledge lies in understanding the interactions between electricity and magnetism, in terms of invisible force fields. This concept of interaction is difficult to explain adequately using non-technical terms. According to Merriam Webster's collegiate dictionary (2003), electromagnetism is described as a branch of physical sciences that deals with the physical interaction between electricity and magnetism. Kurtus (2012) described the interaction between electricity and magnetism as one of the fundamental interactions of matter that acts as a force between electrically charged particles at the subatomic level. On a larger scale, Kurtus explains electromagnetism as the creation of magnetic fields from the movement of electrical charges. Many modern electrical gadgets such as transformers, chargers, electric fans, electric generators/dynamos, microphones, electric bells, electromagnetic flowmeters, and galvanometers operate based on the principle of electromagnetism. This means that the concept of electricity and magnetism is significant to the use of modern technologies, so learners need to understand the scientific principle behind the application of this concept.

Electricity and magnetism is one of the significant and challenging physical sciences topics at all school levels which deals mainly with forces and fields related to charge (Saglam & Millar, 2006). This is a topic that forms one of the core knowledge areas in the Further Education and Training (FET) physical sciences curriculum, and it comprises 36.6 % of the final physical sciences matriculation examination within the South African context (DBE, 2011). Teaching electricity and magnetism at the secondary school level involves many conceptual areas. These conceptual areas includes topics such as magnets, electric and magnetic fields, electrostatics, electric circuits, electrical components, electrodynamics, electric motors, generators, electromagnetism which also deals with content like Faraday's law of electromagnetic induction, magnetic fields and lines, magnetic flux, Fleming's right hand rule, Lenz's law, force on a conductor, electromagnets, eddy currents, transformers, electromagnetic induction, electromagnetic field, alternating current generator, transmission of electric power and self-inductance. Research indicates that learners have difficulties in conceptually understanding this branch of physics due to the complexity and abstract nature of the topic, and misconceptions of both teachers and learners (Engelhardt & Beichner, 2004; Gaigher, 2014; Guisasola, Michelini, Mossenta, Testa, Viola & Testa, 2007; HieggeIke, Maloney, O'Kuma, and Heuvelen

(2001). To deepen the understanding of learners' learning in electricity and magnetism, an assessment tool called Conceptual Survey of Electricity and Magnetism (CSEM) was designed by HieggeIke et al., 2001). This assessment tool has been modified and adapted across many countries and the results are discussed in the next section.

2.3.1 Conceptual design for assessing learners understanding of electricity and magnetism.

A conceptual test called Conceptual Survey of Electricity and Magnetism (CSEM) was designed by HieggeIke et al. in 2001. The concept inventory consists of 32 multiple-choice question used in assessing learners' theoretical knowledge in electricity and magnetism. HieggeIke and colleagues administered this survey to more than 5000 introductory physics learners at thirty different institutions across America. Results obtained from the survey revealed that learners have difficulty understanding how charges are being distributed on conductors and insulators. They also indicated that learners confuse the magnetic effect of moving charges with Coulomb's law. HieggeIke and colleagues explained that learners find it challenging to understand the application of Faraday's law in cases where they cannot relate the concept of a collapsing loop to a change in magnetic flux.

Planinic (2006) conducted a study in America (n=1000) and Croatia (n=84) by administering CSEM to university students offering algebra and calculus-based general physics courses. He concluded that the majority of the students had difficulty understanding concepts like electromagnetic induction and Newton's third law which are topics associated with electricity and magnetism. Planinic argued that CSEM provides opportunities for comparing different difficult concepts and covers a large conceptual area of topics relating to electricity and magnetism.

Miokovic, Ganzberger, and Radolic (2012) conducted a study with 567 engineering students at the University of Osijek using CSEM to assess the learners' conceptual understanding of electricity and magnetism and to diagnose learners' difficulties in the topic. The study indicated that most of the learners had difficulty understanding electromagnetic induction as a conceptual area of electromagnetism. According to

Miokovic et al. (2012), CSEM is a research-based teaching resource developed to assess learners' knowledge and understanding of mathematical functions used in explaining the concept of electricity and magnetism. The CSEM pretest results conducted by Miokovic et al. (2012) indicated that more than 50% of the engineering students at the University of Osijek acquired very limited knowledge of electromagnetic phenomena during their secondary education. Planinic (2006) and Miokovic et al. (2012) concluded that CSEM can be used as a pretest and posttest method for assessing learners' conceptual understanding of electricity and magnetism.

Saglam & Millar (2006) conducted a study in England (n=152) and Turkey (n=120) using a written assessment which included sixteen analytical questions used to assess high school learners' knowledge of electromagnetism. The result from the study indicated that learners' response to the analytical assessment was inconsistent. This signifies that many of the learners do not have the basic understanding about electromagnetism. Saglam and Millar (2006) argued that electromagnetism is a topic that learners find difficult because they view it as abstract in nature and they develop broad misconception about the topic.

Koudelkova and Dvorak (2014) conducted a study in the Czech Republic, exploring how Czech high school learners (from age fifteen to nineteen) understand the concept of electricity and magnetism. They developed a diagnostic tool consisting of eighteen questions called the Czech Conceptual Test from the area of Electricity and Magnetism (CCTEM). About 200 learners took part in the study during the 2012/2013 academic session and more than 150 learners participated in the 2013/2014 academic session. Reports from this study showed that more than 75% of the total learners engaged in the study did not understand the meaning of change of magnetic flux and they do not know that changing the area of a coil changes the flux. This study shows that learners have difficulty in understanding scientific concepts in electromagnetism.

Engelhardt and Beichner (2004) developed two versions of a diagnostic instrument consisting of 29 questions used in accessing college and high school learners' conceptual understanding of direct current resistive electrical circuits. This test instrument is called Determining and Interpreting Resistive Electric Circuit Concepts

Test (DIRECT). The instrument was given to over thousand learners across university and high school level in the United States. The study revealed that after the teaching and learning of electric circuit as a topic, most of the learners still hold a conception that a battery is a constant source of current in electric circuit connection. Learners also confused basic terms by assigning the properties of voltage to resistance and /or current. According to Engelhardt and Beichner (2004), results obtained from DIRECT also revealed that more females than males hold these misconceptions. This signifies a gender gap in the scores obtained.

Research indicates that there is a widespread use of various test assessment instrument in America which have been designed to support physics teachers' instructions and assess learners' conceptual understanding of electricity at high school, intro- college, university and upper level (AAPT, 2013). These tests include:

- Basic Electricity and Magnetism Assessment (BEMA). This was designed to evaluate learners' qualitative knowledge of fundamental concepts in electricity and magnetism at intro- college and upper level.
- Magnetism Conceptual Surveys (MCS). This test was developed to assess difficulties introductory college learners have with magnetism concepts.
- Inventory of Basic Conceptions – DC Circuits (IBCDC). This was developed to assess basic conceptions of DC circuits at intro college and high school level.
- Electric Circuits Conceptual Evaluation (ECCE). This was developed to assess learners understanding of simple circuits concepts at intro college and high school level.
- Electromagnetics Concept Inventory (EMCI). This was developed to assess learners' understanding of electromagnetics concepts in junior level courses in electrical engineering departments at the upper level.
- Electricity and Magnetism Conceptual Assessment (EMCA). This was developed to assess basic concepts in introductory electricity and magnetism courses, using terms that are familiar to learners on the pre-test and without overly difficult questions that might discourage learners from pursuing physics at intro college level.

- Colorado Upper-Division Electrostatic Diagnostic Free Response (CUE-FR) and Colorado Upper-Division Electrostatic Diagnostic – Coupled Multiple Response (CUE-CMR). These tests were developed to assess skills in first semester upper -level electricity and magnetism such as the ability to visualize the problem, correctly apply problem -solving methods, connect math to physics and describe limiting behaviour (AAPT, 2013).

2.3.2 Learners' difficulties in concepts related to electricity and magnetism

The interaction between electricity and magnetism is fundamental to understanding the natural world and these interactions provide the foundations of most current technology. This implies that it is important for science learners to have a basic understanding of electromagnetic phenomena because electricity and magnetism are being viewed as a central topic in the general science and physics curriculum at any teaching level (Guisasola et al., 2007). However, the concepts and models involved in electricity and magnetism are particularly problematic, highly abstract and their understanding is dependent on models (Hekkenberg et al., 2015; Guisasola et al., 2007).

Several studies have been conducted on learners' difficulties and misconceptions related to topics under electricity and magnetism (Engelhardt & Beichner, 2004; HieggeIke et al., 2001; Raduta, 2005), but few studies have been conducted on teachers' understanding and their awareness about learners' difficulties of concepts relating to electricity and magnetism (Gaigher, 2014; Hekkenberg et al., 2015; Moodley, 2013). Learners develop a conceptual understanding of their surroundings as they grow up, by attaching meaning to ideas obtained from everyday experiences, which do not align with scientific knowledge and concepts (Alwan, 2011). These learners go to school taking these preconceived ideas with them and such ideas are not compatible with established scientific laws and theories. These preconceived ideas are learners' previous knowledge about the natural phenomenon or scientific principles, which are incorrect. According to Alwan (2011), these conceptions are in the form of knowledge embedded in culture, language, and traditions of the learners' immediate society. When learners take such conceptions to the classroom, these misconceptions are often resistant to change and can hinder the teaching and learning process (Halim, Yong & Meerah, 2014). It is important that teachers are aware of their learners' difficulties and misconceptions.

Studies have also shown that learners still have difficulties in specific topics after attending a series of classes (Alwan, 2011; Saglam & Millar, 2006). Research on learners' difficulties in physical sciences has become a major concern for the science education community and an important instrument for Physical sciences teachers (Dhurumraj, 2013; Gaigher, 2014; Marusic & Slisko, 2012; Mji & Makgoto, 2006; Osborne, Driver & Simon, 1998). Raduta (2005) indicated that learners' difficulties in electricity and magnetism are associated with underlying misconceptions. These difficulties include applications of Faraday's law, understanding of the interaction between electric charges and magnetic fields, erroneous interpretation of symbols and ambiguous presentations from textbooks. Other difficulties include explanations of direction associated with the Lorentz force, application of the right-hand rule, mechanics misconceptions, misuse of mathematical tools, and learners' perception of the "static nature" of electric and magnetic fields.

Saglam and Millar (2006) claim that learners make common errors in electromagnetism such as having difficulty solving problems related to the rate of change of a variable, application of cause-effect reasoning in situations where it does not apply, considering field lines as directing a flow, and misinterpretation of magnetic and electric field effects. The Department of Basic Education claims that learners experience difficulties in conceptual areas of electricity and magnetism such as the electric circuit, electrodynamics and electrostatics (DBE, 2015, p.183). The following misconceptions and difficulties were identified as some of the learning challenges associated with concepts related to electricity and magnetism amongst South African learners:

- difficulty in identifying the direction of the net field,
- use of incorrect equations to solve problems and poor mathematical manipulation,
- inability to state and apply Ohm's law correctly,
- poor understanding of the vector nature of electric fields,
- inability to simplify complex circuits,

- incorrect use and manipulation of the parallel resistors formula,
- inability to interpret Faraday's law of electromagnetic induction,
- inability to integrate concepts learned under Newton's law with electrostatics,
- inability to differentiate between electromotive force and potential difference (DBE, 2015).

The concepts of electric field, Faraday's law, electric circuit and magnetic field associated with current carrying conductors are significant to modern technologies and central to electricity and magnetism. It is, therefore, necessary for learners to know how to identify directions of fields and develop methods of solving the problem on related questions. Teachers also find it difficult to change learners' existing misconceptions associated with electricity and magnetism, despite the scientific explanation behind the topic (Gaigher, 2014; Saglam & Millar, 2006); this could be due to teachers' concept confusion and inadequate understanding of the topic (Hekkenberg et al., 2015). Often, teachers are not properly trained but are required to use different teaching strategies to teach different scientific concepts and lesson content. Though there is no universally accepted strategy in teaching science, research experience shows that there are general principles and effective teaching strategies that promote learners' conceptual understanding of science (AAAS, 2010).

These general principles and teaching strategies include use of the interactive lecture approach which includes encouraging learners' participation, learners' engagement in collaborative activities, field trips, concept mapping, games, sense making discussion sessions, argumentation and role-playing, use of laboratory practices which includes hands-on activities or practical demonstration, bridging analogies and explanatory models, presentation of abstract concepts followed by specific worked examples, use of technology such as computer-based visual techniques, simulations and software; conceptual problem solving and discovery approach, use of guided inquiry-based method and integration of multiple representations (AAAS, 2010).

The main purpose of teaching physical sciences is to help learners discover and understand how the physical world works. Hence it can be said that physical sciences is a tool to train learners to be able to use complex scientific concepts in solving challenging problems. It is, however, important to provide teachers with learning opportunities that can help them detect conceptual difficulties experienced by science learners and, reinforce and expand their knowledge on how best to teach difficult concepts in electricity and magnetism (Halim et al., 2014).

2.4 Professional development of physical sciences teachers

Hassel (1999) describes professional development as a method of revamping skills and competencies of staff required to produce outstanding results for learners. Atencio, Jess, and Dewar (2012) suggested that teachers should see themselves as learners if they want to remain and become experts in the profession. This implies that teachers should continuously engage in programmes that would provide them the opportunity of learning. Such learning experiences should be teacher- driven, affiliated to application, reflective and public-oriented to support professionalism. Teachers' professional development is a systematic, planned and continual process of learning activities taking place in a work-related environment with the aim of positively impacting the individual, school, and nation at large (Gabriel, Day, & Allington, 2011; Guskey, 2002). According to Bredeson (2002), alternate terminologies have been used instead of professional development and such terms include in-service training, continuing education and self-development programmes. Nevertheless, studies have reported that teachers' professional development is the foundation of any country's successful education reform (Gabriel, Day, & Allington, 2011; Guskey, 2002). These studies claim that professional development is crucial to the success of any reform programme, provided it is concerned with the continuous learning of individuals, school improvement, and policy implementation.

Hanushek (2011) points out that the effectiveness of a teacher is dependent on the quality of teaching and instruction given to help learners develop their learning skills and achieve better results. Education in the present millennium is experiencing a global reform which focuses on teacher professional development as one of the essential features in improving teachers' competence and effectiveness**.** Though the concept of teacher professional development is not new, the way in which it is being organised and administered has taken a modified form (Kriek & Grayson, 2009). Research indicates that effective professional development enhances teachers' competence and improves learners' learning (Darling-Hammond, Hyler & Gardner, 2017).

The Government of South Africa initiated a programme in 2011 called Integrated Strategic Planning Framework for Teacher Education and Development (ISPFTED). The program was developed to revamp the education system of South Africa by improving teachers and teaching quality through research-based teacher education and professional development programmes (Centre for Development and Enterprise (CDE), 2015; Withers, 2011). Hence, achieving quality education and better learners' performance in schools require teachers to have a personal drive to evolve new ways to help learners enjoy their lessons, retain most of what they have learned and be ready to learn. Studies conducted on teachers' professional development demand that teachers regularly update their knowledge base through continuous participation in development programmes aimed at improving their professional competence, classroom teaching experiences and yielding better learners' outcome (Coe et al., 2010; Ono & Ferreira, 2010).

Mji and Makgato (2006) claim that inadequate pedagogical content knowledge and subject matter knowledge of teachers are direct factors responsible for the poor performance of physical sciences learners in South Africa. To increase the quantity and quality of passes in physical sciences, Kriek and Grayson (2009, p.199) argued that teachers need to simultaneously "*develop their content knowledge, teaching approaches, and professional attitudes*". This implies that there is a need for physical sciences teachers to engage in professional training courses aimed at improving their professional knowledge and classroom practice. It is critical for teachers to view professional development training as opportunities offered to them with the intention of acquiring more knowledge, skills, approaches, and dispositions towards improving their teaching. Teaching approach as required in this study involves participants' abilities to apply the various teaching principles, beliefs and ideas to learners' learning. It is clear that physical science teachers need more hands-on and quality professional development programmes that are critical to the retention and improvement of their classroom practice because of emerging teaching strategies. To develop effective and efficient physical sciences teachers in the South African schooling system, there is a need to learn about the professional development of science and physics teachers in developed countries.

2.4.1 International perspectives on professional development of physical sciences teachers

It is evident that the teaching position in science education, especially in the field of physical sciences, is experiencing a constant change due to science and technological advancement. This means that physical Science teachers are required to modify and adapt their teaching strategies to these changes. The American Association for Employment in Education (AAEE, 2008) reported that the posts of physics teachers at the secondary school level is one of the most difficult teaching positions to fill. More so, the AAPT (2013) points out that teaching strategies in the field of physics are improving due to an ongoing transition in physics education research. These reports indicate that quality professional development is critical to the retention and improvement of any physics teacher in the classroom.

Hodap, Hehn, and Hein (2009) reported that the physics society has clarified the increasing need for physics teachers in secondary schools. A survey carried out by the American Institute of Physics (AIP, 2010) confirms that in 70% of the 500-observed physics departments across the USA, there were no teachers with a physics education background. The analysis from the AIP's report prompted policy makers and scientists in America to form the National Institute for Physics Teacher Educators (NIPTE). The aim of the NIPTE programme is to develop leaders in the education sector capable of addressing the critical shortage of secondary school physics teachers through teacher education programmes. NIPTE was also designed to give professional training and workshops to physics teachers willing to improve their teaching practices within the field of science.

Osborne and Dillon (2008) argued that Science Education in Europe has been a major concern due to the decreasing number of learners who choose to study science at the tertiary level particularly in the field of physics. However, physics and science teachers in Europe continuously develop themselves through a systematic and continuous professional development programme to educate young people about the scientific development and changes in the field of science and technology (Bolte, Holbrook, Mamlok-Naaman, & Rauch, 2014). According to Aiello and Watson (2010), in order to promote the standard of learners' achievements in science subjects in the UK, physics teachers should see themselves as teacher researchers and engage in career-long continuing professional development. The AAPT (2013) suggested that physical sciences teachers who wish to improve their effectiveness in the classroom should engage in continuous professional development. Such professional development may include active involvement in professional organisations such as local sharing groups, state and national science associations; participation in workshops and programmes that provide exposure to first hand methodologies and encourage collaboration with other teachers; enrolling in advanced teacher education programmes focused on development of teaching pedagogy through advanced degrees or seminars, participation in projects that enhance real-world applications of physics through summer research or work experience at laboratories, universities (AAPT, 2013).

The NIPTE emphasised the need for standard professional qualifications of physical sciences teachers. They argued that the professional development of physical sciences teachers must focus on improving teachers' knowledge of content and pedagogy. According to Vavrus, Thomas and Bartlett (2011), the use of learner-centered pedagogy is a critical element in enhancing teachers' pedagogical content l2knowledge (PCK) since learners' learning depends largely on it. This clearly indicates that effective teacher professional development programmes may improve physical sciences teachers' classroom practices and such development programmes can only become effective if they possess the following characteristics:

- Well supported, on-going, and in-depth practice such as tutoring, modelling and common problem solving; it should build or strengthen the community of learning by promoting collaborative and cooperative efforts among physical science teachers; it must be continuous and consciously linked to other parts of the educational system reforms or school change (Darling-Hammond & McLaughlin, 2011).

- Such programmes should give physics teachers the opportunity to evaluate their professional development activities; teach educators how to integrate instructional methods to promote learning; train and assist physical sciences teachers to perform in leadership roles. It must furnish teachers with time to improve and demonstrate their knowledge of content and pedagogy and motivate teachers by explaining the concept of successful teaching and learning classroom practice. (Loucks-Horsley, Stiles, Mundry & Hewson, 2009).

Various studies on teachers' professional development programmes have emerged over the years but according to Darling-Hammond and McLaughlin (2011), a good professional development programme must be centralised around teacher networking, focused on action research practice, promote individual guidance and ability to use the power of feedback from observation. Birman, Desimone, Porter, and Garet (2000) highlighted professional development as a key role in addressing the knowledge gap created between teachers, learners and policymakers. Within the context of the American education system, researchers believe that personal drilling of physical science teachers within a real-life classroom context can help in producing effective teachers (AAPT, 2013). Teachers in some part of the western world have started adopting the Lesson Study model as an instrument for promoting experienced learning among teachers and learners (Lewis & Hurd, 2011; Lewis, Perry & Murata, 2006; Ono & Ferreira, 2010). There is an important need for the continuous professional development of South African physical sciences teachers, and this need requires engaging teachers in action research practices like Lesson Study, which is designed to develop effective, sustainable and professional teaching practices among physical sciences teachers.

2.4.2 Physical sciences teachers' professionalism

The poor performance of physical sciences learners over past years has been a major challenge to the Science Education community. According to Anderson and Barnett (2011), these poor performances are attributed to factors like physical sciences teachers' professionalism. This includes teachers' effectiveness, professional competence (knowledge, skills, beliefs, motivation) and poor comprehension of difficult basic physical sciences concepts, especially in physics. However, Ansari and Malik (2013) point out that teachers' effectiveness is a combination of teachers' competencies, characteristics, and behaviours that enable learners to achieve their desired outcomes, such as attaining outlined learning goals, ability to think critically, solving problems and working together with colleagues thereby becoming self-regulated and independent learners. A study conducted by Medley (1977) explains that the measure of effectiveness is an indicator of teachers' competencies. In other words, an effective teacher is always competent, but a competent teacher may not always be effective due to several reasons. This implies that producing learners with good academic performance can only be possible if physical sciences teachers are competent and effective in teaching the required scientific skills and concepts. For this research, some teacher-related factors that might affect physical sciences teachers' competencies and probably contribute to the low academic achievement of learners in the subject, will be reviewed.

2.4.2.1 Teaching and teacher quality

There are several physical elements that play supportive roles in the successful reform of educational policies and curriculum implementation in any school. These physical elements fall in the context of school-related factors; but teaching quality is being regarded as the most significant school-related factor that influences learners' academic achievement (Rivkin, Hanushek & Kain, 2005) and serves as a pillar on which the school depends for success. It is believed that quality teaching in schools can be improved when teachers improve their practices. However, research indicates that the level of emotional, social and instructional interaction between a teacher and a learner is an important factor which determines the value of a school and the quality of education received by the learner (Association of Psychological Science (APS, 2010). This implies that there is a common association between quality teaching, teacher quality, and learners' performance.

The definition of teacher quality is a complex task which varies from country to country based on teaching standards developed by the accredited teacher education organisation. According to Greenberg, Rhodes, Ye, and Stancavage (2004), the United States No Child Left Behind (NCLB) Act of 2001 described the term teacher quality as a complex phenomenon used in describing qualified teachers in terms of competency and effectiveness obtained through teacher preparation, teacher qualification, and their teaching experiences. This implies that a quality teacher must hold a minimum qualification of bachelor’s degree, full state certificate and ability to demonstrate skill competency in the subject that he or she teaches. The NCLB act indicates that all teachers recruited into public or private education system must be highly qualified. Research claims that teacher quality is a terminology used to describe a competent and effective teacher (Berliner, 2005). Teacher quality in terms of physical, moral and intellectual ability sometimes determine the levels of teacher competence and effectiveness. Teacher quality is a significant school factor that can positively improve a learners’ academic achievement. Several teacher characteristics are required to determine the quality, competence, and effectiveness of a teacher. These characteristics include qualification/certification, experience, confidence, coursework, subject matter knowledge and individual test scores. However, the concept of teacher quality focuses on the characteristics used in determining teachers competence which includes qualification, years of experience, cognitive abilities and impact on learners’ outcomes. Therefore, the term teacher quality as used in this study refers to the knowledge, characteristics, capabilities and skills of a teacher. However, Kola and Sunday (2015; p.10) described teachers’ qualification as “a particular skill or type of experience or knowledge someone possesses to make him or her suitable to teach”. It seems that the word teacher qualification is used ambiguously.

Teacher qualification ordinarily refers to the formal degree or certificate or diploma awarded by an institution such as a university or a college. Darling Hammond (2000) claims that there is a remarkable correlation between a learners’ performance and the teachers’ qualification. It is possible that teachers who qualify for teaching positions through colleges of education are likely to teach in specific ways based on the training received. In other words, it can be said that the type of academic qualification a teacher receives contributes to how the teacher performs in his or her classroom. Therefore, teacher quality correlates to their qualification.

The education system in South Africa is facing many challenges including insufficiently qualified teachers who cannot effectively and competently provide quality teaching to learners (CDE, 2015). For instance, research indicates that the quality of previous initial teacher education programmes in South Africa has a negative effect on the current teaching force due to inadequate training during the apartheid period or in the recent past (CDE, 2015). It seems that some of these teachers are not committed to the profession because they were never interested in teaching and they did not get enough support to motivate them on the job. Similarly, newly recruited teachers are not properly inducted into the profession either at the provincial and district level; instead they are expected to adapt to whatever situation they find themselves in at their new school. However, Parker (2011) indicated that improving the image of the teaching profession could help in upgrading the quality of physical science teachers. He believes that the education system can improve teachers' quality by conducting an induction programme for those newly recruited into the profession. Also, supporting the new and old teachers by sending them on research based professional development programs, motivating the teachers by organising workshops and seminars that address real-life classroom situations and encouraging teacher collaboration programmes across the provinces and districts would retain them in the profession (Parker, 2010). Though there are many talented teachers teaching physical sciences, most of them are either under-qualified or unqualified (Stephen, 2013). The National Strategy for Mathematics, Science and Technology Education (NSMSTE) was designed to improve the standard and competence of unqualified teachers in the country (DoE, 2001); yet there is no clear evidence of the impact this strategy has on physical sciences learners' performance (Ngobese, 2014). South Africa need quality teachers who are qualified, competent, effective and well trained to meet the growing challenges and the scientific needs of the country. Efforts to improve teacher quality and teaching quality among South African teachers have been ongoing for several years. These efforts have included the introduction of different ongoing continuing professional development programme across the nation, revision of the curricula, teacher support through the Integrated Quality Management System and the Quality Learning and Teaching Campaign (Gaigher, Lederman & Lederman, 2014).

A study conducted by Basson and Kriek (2012) on physical sciences teachers' ability to teach physics at the FET level, reveals that 40% of the participants had either Bachelor of Science (BSc) or Bachelor of Science Education (BSc. Ed) degrees while others had teaching diplomas. However, 80% of the participants taught physical sciences at the FET level without having a major qualification in either physics and/or chemistry. Teachers that fall into this category are unqualified but unfortunately, you find them in the teaching profession. This implies that the poor performance of physical sciences learners could be related to the recruitment of unqualified teachers who lack basic knowledge of the subject content (Mji & Makgato, 2006). Also, there are teachers who have the acquired teaching qualification yet do not have the basic understanding of the subject matter. There may also be teachers with good teaching methods and a basic understanding of the subject matter due to training but who do not have the required teaching qualification. However, teaching method consist of a combination of activities that teachers carry out in order to accomplish their teaching. CDE (2015) argues that there is more to being a good teacher than qualifications. This implies that being a qualified teacher does not mean he/she is capable of providing learners with quality science instruction.

Parker (2011) claims that a policy framework was set up in 2007 to address the urgent need for trained teachers and enhance the standard of teacher training programmes in South Africa. However, the success of South Africa's schooling system and learners' academic achievement solely depends on the individual effort of teachers, their dedication, and continuous self-discipline. This implies that a school is as good as its teachers. There is need to develop physical sciences teachers' competency through ongoing professional development, to enable them to become quality teachers with the aim of meeting the challenging needs required for the 21st-century education system. Research claims that a desirable attribute of teacher quality is associated with good subject knowledge, relationship with learners, dedication, accessibility, hard work, classroom management and teaching skills (Mji & Makgato, 2006). Hence, it is possible that the quality of physical sciences teachers depends on the nature of their training and level of preparation.

The South African Council for Educators (SACE) is a registered professional body for teachers in South Africa. SACE was established with the aim of improving the teaching profession by registering certified teachers, managing teacher professional development programmes and inculcating ethical conducts for all teachers in the country. Teacher certification ensures that every teacher appointed to any phase of the education system is competent to teach the subject matter. Such a teacher must be well trained, rigorously screened and able to carry out other teaching activities expected by the professional body. Currently, teacher certification in South Africa requires that any individual who wants to become a professionally qualified teacher must have undergone a four-year Bachelor degree programme in Education (B.Ed.) or any three years Bachelor's degree programme accompanied by a one-year Postgraduate Certificate in Education (PGCE). Such candidates are entitled to register with the country's professional educator's council SACE after possessing the necessary qualification. CDE (2015) claims that a large number of South African teachers are qualified with M+3 (matric plus three years of initial teacher education). This was the official requirement in the country until recently when the approved requirement for a qualified teacher was changed to M+4 (matric plus four years of initial teacher education). Some countries require that teachers write tests or examinations on fundamental skills, subject knowledge, and/or teaching methodology before they can have an initial or continuing membership of the teaching license (Darling-Hammond, 2000). Therefore, professional bodies should measure teacher qualification, which combines the content and pedagogical knowledge of a subject through teacher certification (Darling-Hammond, 2000). According to Darling-Hammond (2000), teacher certification / licensing is viewed as one of the strongest variables of teacher qualifications in the United States and this was evident by the wide difference between the performance rate of black and white learners. Research on student performance at the school level and district level reveals that teachers' qualifications, which includes scores on licensing examinations, have a substantial influence on learners' learning (Darling-Hammond, 2000).

Another significant factor that influences teachers' quality and learners' performance is years of teaching experience. A report shows that teachers with three or more years of teaching experience are more likely to have accumulated the necessary skills, knowledge, and experience required to communicate their instructions effectively to learners (Darling-Hammond, 2000). Basson and Kriek (2012) argued that though teachers with more than five years of teaching experience are better conversant with how to implement the curriculum due to their experience and general work, many of them might also find it difficult to change their teaching practice because they are already used to a certain working system. More so, other studies have revealed that teaching experience and educational qualification influence teachers' subject matter knowledge (Darling-Hammond, 2000; Kola & Sunday, 2015). A study conducted in Kenya on teachers' qualifications and learners' performance in science subjects reveals that poor teacher qualification and lack of experience has a significant contribution to the low academic performance of learners in science subjects (Musau & Migosi, 2015). It is very important to know that a teaching qualification does not guarantee adequate understanding of the subject and knowledge of the required pedagogy. CDE (2015) claims that policies on minimum requirements for teacher education qualifications are being implemented as one of the ways by which challenges facing the quality of teachers and teaching in South Africa can be addressed.

However, the Lesson Study process may be an effective model of professional development that will improve teachers' quality in terms of knowledge and skills through group discussions, collaborative efforts or self-reflection on learners' learning behaviour and performance.

2.4.2.2 Teachers' professional knowledge

The issue of teachers' professionalism has been a subject of controversy in the research community for quite some time. There has been a series of ongoing debates by researchers and scholars on the importance of recruiting professional teachers in schools. The teaching profession is a complex one that requires teachers to be well equipped and updated with most relevant skills, expertise, and knowledge to be qualified and competent in educating learners. Teachers as key agents of change should use every available opportunity to develop their professional knowledge and practice. Teachers are role models for the learners and the society they live in because the character they portray has a deep impact on these learners. Ansari and Malik (2013), described teachers' professional knowledge as the awareness of their commitment to their learners. However, physical sciences teachers' ability to enhance their learners' scientific skills and knowledge application depends on their professional knowledge.

Shulman (1987) described teachers' professional knowledge as the knowledge base required for teaching which answers the question of what teachers' need to know. Shulman proposed the following categories of teachers' knowledge:

- Content Knowledge
- Pedagogical content knowledge which involves teachers' ability to merge content and pedagogy for learners understanding
- General pedagogical knowledge which involves harmonisation of general teaching principles and strategies for effective organisation of the learning environment
- Knowledge of learners and their characteristics
- Curriculum knowledge which involves teachers' effective use and combination of instructional resources and curricula as teaching instruments;
- Knowledge of educational settings;
- Knowledge of educational goals.

Shulman emphasised the importance of pedagogical knowledge as an important category of teachers' knowledge. He argued that,

> pedagogical content knowledge is of special interest since it identifies the distinct bodies of knowledge for teaching. It represents the blending of content and pedagogy into an understanding of how particular topics or problems are structured, represented, and adapted to the various interest and abilities of learners, and presented for instruction (Shulman,1987, p.8).

He assumes that pedagogical content knowledge differentiates the understanding of the content specialist from that of a pedagogue.

Tamir (1988) argued that professional knowledge domains for science teachers include specific topics taught, general pedagogy, topic-specific pedagogy, general education, personal experiences and foundational knowledge of the profession. Judging from this, it is clear that the professional knowledge of teachers is centred around their pedagogical content knowledge. Jones and Straker (2006) further points out that the professional knowledge of teachers include content knowledge (which involves knowledge of the subject matter, knowledge of learners' background and the school's organisational culture), pedagogical content knowledge (how a teacher re-contextualises his or her content knowledge so that it can be understood by the learner), and general pedagogical knowledge (a combination of the teachers' knowledge of various teaching strategies, classroom management and assessment skills) . Whatever model has been proposed for teachers' professional knowledge indicates that the knowledge base for science teaching has clearly changed over time due to trends in scientific innovation and change in the science curriculum.

Zeidler (2002) argued that science teachers could only fulfill their role as quality teachers if their professional training is focused on knowledge of content and pedagogy. Unfortunately, most teacher training programmes produce teachers with inadequate knowledge and skills. The strategic outline set up by the Policy Framework for Teacher Education and Development in South Africa was intended to help teachers acquire and develop the behaviour needed to successfully complete their responsibilities, continually develop their performance and competence, to empower teachers by improving their professional self-efficacy, subject knowledge, skills and classroom management and to improve their professional status as teachers (DoE, 2007). This implies that teachers' professionalism is not restricted to their cognitive knowledge but also includes their affective characteristics in terms of competence, attitudes, skills and motivational variables that support the mastery of effective teaching and learning (Blömeke & Delaney, 2012). The general view of a quality teacher is a teacher with an extensive knowledge of the subject he/she is to teach and a strong understanding of resources used in teaching. When the teachers' subject knowledge is not adequate, it brings about a setback in the learners' learning process. A quality teacher should have a knowledge of how his/her learners think and can evaluate the subject content in relation to the learners' thinking ability, thereby identifying learners' common difficulties and misconceptions in the subject. Mji and Makgato (2006) claimed that teachers' knowledge of subject matter alone has little or no significant effect on learners' understanding if not combined with good teaching methods. This implies that the effectiveness of a physical sciences teachers does not depend on content knowledge alone; but also on classroom climate and management, quality instruction, professional behaviours, teachers' beliefs, and skill management. Teachers' beliefs as used in this study refer to subjective ideas, thoughts and obligations held at different degree of persuasion to understand teachers' practice. Physical sciences teachers in South Africa need to possess individual effective and efficient knowledge and skills required to work with learners in developing a conceptual understanding of the subject they teach and achieve a good learning outcome.

Considering the challenges faced when teaching science in the 21st century, Corrigan, Dillon, and Gunstone (2011) suggested that the knowledge base for science teachers should focus on teachers' intellectual work, work organization and, the social and cultural context of science teaching. Teachers' professional knowledge is therefore described as the teaching knowledge (content knowledge, knowledge of teaching strategies, knowledge of learners' difficulties and general pedagogical knowledge) required by teachers. In this regard, a brief discussion of the three common elements of teachers' professional knowledge identified across all models reviewed in this study is given. These elements include content knowledge, pedagogical content knowledge, and general pedagogical knowledge .

Teachers' content knowledge

According to the American Physical Society education programmes, considerable research evidence indicates that a higher percentage of learners' success in physical sciences is associated with their teachers' preparation and training (AAPT, 2013). AAPT describes a physics teacher as a representative of the teaching community who has a broad and updated knowledge of the major content areas in the field of physics. A deeper understanding of physical science content will make a significant difference in teachers' classroom instruction and their learners' academic achievement. Ideally, a good physical science teacher should be able to master the basic content knowledge through inquiry methods and have the opportunity to experience the process of scientific investigation before coming to the classroom. They argued that the knowledge gained by teachers before going to class will help enhance their confidence and facilitate the use of good classroom practices in promoting learners' confidence and performance in the subject.

Content knowledge (CK) or subject matter knowledge refers to a body of information containing facts, laws, theories, principles, and concepts in a specific subject area that teachers should teach their learners. According to Shulman (1987), teachers develop a deeper knowledge of the subject matter if they have been planning and teaching specific content over time. More so, adequate knowledge of subject matter is essential to good teaching (Darling-Hammond, 2000). If physical science teachers do not have the adequate understanding about the subject matter, they provide learners with inadequate information and learners will practically develop difficulties and misconceptions about the content of the subject. A study conducted by Mji and Makgato (2006) in South Africa indicated that many teachers admitted to the shortcomings they have in specific content areas of the subject being taught. Teachers' poor knowledge of physics concepts tends to hinder learners' conceptual development and performance in physical sciences. A Report from Basson and Kriek (2012) indicated that physical sciences teachers in schools within urban and rural areas have insufficient content knowledge of the subject. It is necessary for organisers of professional development programmes to place emphasis on strengthening the content knowledge of physical sciences teachers.

The teaching profession requires that teachers have a good understanding of the subject they teach, and be able to help learners develop a rich understanding of the subject and how the subject matter is created, organized and linked to other disciplines (Ball & McDiarmid, 1989). This implies that teachers' accumulation of information on how to teach a specific subject is an integral part of developing a teachers' content knowledge (Shulman, 1987). More so, when teachers have an extensive knowledge of the subject they teach, identifying and addressing common difficulties and misconceptions that learners bring to the classroom becomes an easy task (Mji & Makgato, 2006).

General pedagogical knowledge

Research literature describes General Pedagogical Knowledge (GPK) as the overall knowledge expected of a teacher to function effectively in the teaching profession (Morine-Dershimer & Kent, 1999). This includes knowledge of various teaching and learning strategies, classroom management and organisation, evaluation strategies, a deeper understanding of the classroom communication process and principles that cut across other disciplines. According to Mishra and Koehler (2006), General Pedagogical Knowledge (GPK) deals with how teachers apply their knowledge of social, cognitive and developmental learning theories to learners' classroom learning.

In order words, a physical sciences teacher with a deep understanding of what general pedagogical knowledge entails will be able to understand how learners construct their knowledge and develop an attitude towards learning the subject. General pedagogical knowledge is an essential aspect of the teaching profession that deals with teachers' demonstration on how to manage classroom instructions, thereby increasing learners' motivation and interest in the subject.

Shulman (1987) viewed GPK as the different aspects of how teaching is accomplished which include broad principles of classroom management and organisation that helps in transforming teachers' content knowledge or subject matter. Shulman argued that teachers acquired general pedagogical knowledge through education and accumulation of individual experiences. A study conducted by Sothayapetch, Lavonen and Juuti (2013) in Finland and Thailand on primary school teachers' pedagogical knowledge, reports that most of the teachers were flexible in handling their learners and that pedagogical knowledge does not require a specific technique. Regardless of the country, GPK and PCK remain the fundamental forms of the knowledge base for science teaching. Professional development of physical sciences teachers involving GPK is very important since it gives teachers a better understanding of their responsibilities. General pedagogical knowledge helps newly appointed teachers to understand their learners and the whole school educational system. This type of knowledge also helps in building teachers' understanding of the subject instructional resources and curriculum. General pedagogical knowledge is very important for physical sciences teachers to enable them to secure the framework of mental readiness needed by learners to properly comprehend and understand physics lessons like electricity and magnetism. Nevertheless, the performance of a teacher in terms of quality depends on how the teacher integrates general pedagogical knowledge and content knowledge of the subject to teach.

Pedagogical content knowledge

PCK represents the understanding of how specific topics are modified in terms of content and pedagogy and presented as instructions to learners of different abilities and interest (Shulman, 1987). Shulman argued that PCK distinguishes the knowledge of a pedagogue from that of a content specialist. More so, other studies have identified teachers' pedagogical content knowledge as a core cognitive element of teachers' professional competence (Blömeke & Delaney, 2012; Jones & Straker, 2006; Kunter et al., 2013; Tamir, 1988). Van Driel et al. (1998) related pedagogical content knowledge to a teachers' craft knowledge which consists of combined knowledge in the form of teaching method, the content of the subject and knowledge of the curriculum that teachers accumulate over time. According to Van Driel et al. (1998), newly recruited teachers have little or no pedagogical content knowledge without classroom teaching experience, so teachers develop their pedagogical content knowledge through continuous personal teaching experience and exposure to learners. In other words, PCK refers to the methods teachers use in transferring their content knowledge to learners. Shulman (1986) argued that general pedagogical skills are insufficient for the planning and preparation of subject content for teaching. Research, however, seems to reveal that teachers' understanding of content knowledge has no significant influence on classroom teaching if not properly accompanied with good teaching strategies (Mji & Makgato, 2006). Therefore, the practical knowledge required for the teaching profession is pedagogical content knowledge since it rests on the interaction between content and pedagogy.

The concept of pedagogical knowledge and pedagogical content knowledge are significant in teaching physical sciences. Mji and Makgato (2006) claim that pedagogical content knowledge is been identified as the foundational knowledge that teachers need to enable them to improve learners' poor performance in physical sciences. Though physical sciences teachers are prepared through varieties of programmes offered by universities and colleges of education, it seems that these educational courses focus on content and pedagogical skills and not on how to teach specific science concept that learners find difficult to understand. Sadler, Sonnert, Coyle, Cook-Smith, and Miller (2013) argued that most physical sciences teachers understand the content they teach but are unable to identify and address learners' difficulties and misconception in specific concepts. Pedagogical content knowledge will help such teachers to translate their subject content knowledge into useful representations of ideas in the form of "powerful analogies, illustrations, examples, explanations, and demonstrations" to facilitate learners' comprehension (Shulman, 1986, p.9). To enhance learners' performance in subjects like physical sciences, professional development programmes should aim at improving teachers understanding of learners' difficulties, misconceptions and learning behaviour (Van Driel et al., 1998). Effective teaching involves having a comprehensive knowledge of the subject matter and understanding the different ways of communicating the content of the topic to enable easy comprehension by all the learners. However, reports have indicated that physical sciences teachers may lack the required knowledge (subject and pedagogy) needed to teach outlined physics concept in the CAPS curriculum (Basson & Kriek, 2012). This implies that there is an urgent need and demand to improve physical sciences teachers' PCK through research-based professional development programmes.

2.5 Lesson Study as a practical model of teachers' professional development

> *Taking the time to reflect critically on the things we are doing in our classroom is perhaps the most effective thing we can do to ensure that what we are doing is having the desired outcomes and is changing our practice in the ways we want it to. (Wenmoth, 2007).*

Teaching is a cultural and complex activity embedded in a certain context to understand and provide solutions to learners' academic challenges (Ebaeguin & Stephens, 2014; Stigler & Hiebert, 2009). The goal of every professional development programme is to improve the teaching and learning process. Lesson Study is a professionally developed educational approach that emerged in the Meiji period of Japan (1912 to 1968), from a culture where people rely on traditions, close relationship, implicit communication and shared sets of knowledge to provide the context within which to understand the teaching and learning process. This foundational culture positively contributed to the sustainability of desired pedagogy, classroom practices and teacher interaction that comes with Lesson Study as a model of a teacher professional development programme (Ebaeguin & Stephens, 2014; Pjanic, 2014).

2.5.1 Lesson Study in international research

Lesson Study is described as a classroom inquiry model which requires teachers to work together in small groups as they jointly plan, teach, observe, analyse and refine classroom lessons to improve their teaching practice (Cerbin & Koop, 2006; Coe et al., 2010; Fernandez, 2002; Ono & Ferreira, 2010; Pang & Ling, 2012; Stols & Ono, 2016). Lesson study is a kind of action research model that focuses on improving teachers' knowledge and learners' outcomes. The process of developing teaching within the context of Lesson Study requires teachers coming together to plan a lesson, observe the teaching and learning process during the lesson, evaluate the content of the lesson and mode of delivery, use suggestions from evaluation to prepare a better lesson. This implies that Lesson Study is a model of enquiry where people work together in a community of practice with focus on teachers' improvement and learners' learning. The interest in Lesson Study was prompted by Stigler and Hiebert in 1999 when they published a book titled *''The Teaching Gap''.* As part of the Third International Mathematics and Science Study (TIMSS), the book analyzed the video study of Grade 8 mathematics lessons from Germany, Japan, and the United States. Regarding lessons, Japan was rated as the only high performing country due to their (i) presentation of mathematics content (ii) relation between coherence and connections of content (iii) evidence of learners' thinking and reflection during lessons. Several studies have indicated that the practice of Lesson Study has been extensively credited for the consistent upgrade of Japanese elementary mathematics and science teaching after their high achievement in TIMSS (Pang & Ling, 2012; Stigler & Hiebert, 2009; Stols & Ono, 2016). Consequently, the approach has been widely adopted across other parts of Asia, Europe, and the United States. Instead of Japanese teachers working separately when it comes to teacher development, a collective method is practiced through Lesson Study with a joint attempt to study classroom lessons. This is done to establish practical amendment for their instructional practices and improve learners' learning. According to Lewis & Hurd (2011), Lesson Study has four phases, which are:

- Goal setting based on desired objectives, which involves considering life-long goals for learners' learning and progress, studying guidelines and syllabus;

- Planning which involves the development of the lesson plan by selecting or revising research lessons, anticipating learners' responses, and gathering evidence of learners' learning;
- Conducting a research lesson involves teaching the research lesson by one of the group members while others observe the lesson and collect data on learners' learning;
- An in-depth critique of lessons by reflecting, discussing and sharing information on what is learned and its implications for instruction.

A diagrammatic representation of the Lesson Study phases is depicted in Figure 2.1.

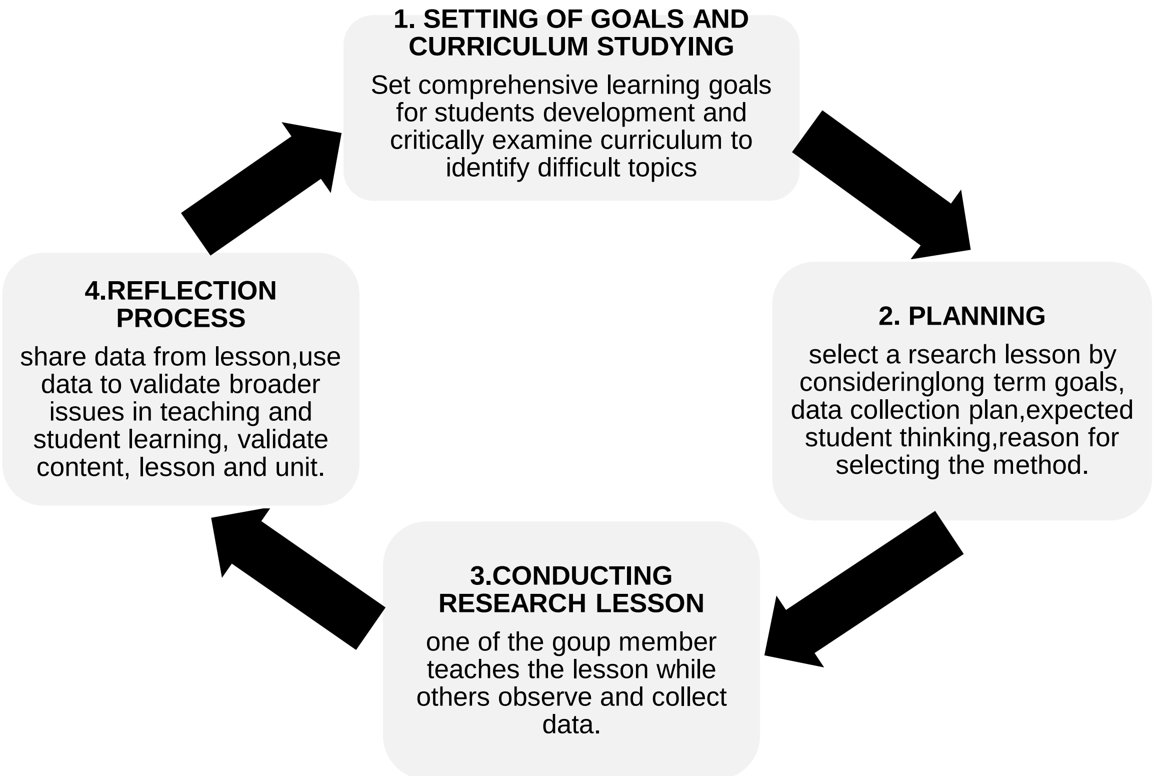


Figure 2-1: The Lesson Study Cycle process (Lewis & Hurd, 2011)

Research indicates that the practice of Lesson Study as a professional growth model enables teachers to reflect about the continuous aspirations of education in terms of having respect for others and love of learning; thoroughly consider the goals of a distinct subject area or lesson; develop classroom lessons which will bring detailed topic and lasting goals for learners to life and have a thorough understanding of how learners respond to lessons through their learning, participation, and manner of behaviour to each other (Yarema, 2010). This implies that Lesson Study is not only an activity in which teachers continuously endeavor to upgrade their approach to teaching by collaborating with colleagues to teach, observe, analyse and revise lessons for their subjects, but also supports teachers' knowledge construction and development of other methods of instruction. Lesson Study became well known by researchers internationally due to its self-development attribute.

Several studies have outlined the positive and significant benefits derived from Lesson Study (Cajkler, Wood, Norton, Pedder & Xu , 2015; Cerbin, 2012; Coe et al., 2010; Dudley, 2013; Fernandez, 2002; Lewis & Hurd, 2011; Pang & Ling, 2012; Posthuma, 2012; Rock & Wilson, 2005). For instance, research indicates that Lesson Study helps to improve teacher learning through critical discourse on filtering invisible tactic knowledge and replacing existing ideas with co-constructed knowledge (Dudley, 2013), since it is believed that knowledge is constructed in a social learning environment through dialogue. Research reveals that teachers have been able to build school professional learning communities and develop their professional knowledge in terms of subject knowledge, pedagogical knowledge and pedagogical content knowledge through the phases involved in Lesson Study (Cerbin, 2012; Coe, 2010; Fernandez, 2002; Lewis & Hurd, 2011; Rock & Wilson, 2005; Stols & Ono, 2016). However, teachers' knowledge should not be limited to their cognitive abilities only, but also include their affective abilities. Studies have shown that Lesson Study also helps in building teachers' professional character, increases teachers self-confidence, increases teachers focus on their learners' learning, improves the learning outcome of learners and the quality of teachers' classroom practice (Cajkler et al., 2015; Cerbin, 2012; Coe, 2010; Lewis & Hurd, 2011; Rock & Wilson, 2005). Other benefits of Lesson Study as reported by reviewed literature reveal that it improves learners' academic achievement due to teachers' learning (Cerbin, 2012; Fernandez, 2002; Lewis & Hurd, 2011; Stols & Ono, 2016). Though Lesson Study supports teachers' natural inclination that continuously improves instruction by taking new initiatives, it focuses more on learners' thinking and learning rather than the teacher (Lewis & Hurd, 2011).

Despite the positive benefits attributed to the practice of Lesson Study, there are challenges and contextual factors that also contribute to the failure, success and sustainable implementation of Lesson Study (Adamson & Walker, 2011; Rock & Wilson, 2005; Saito & Atencio, 2013). Research indicates that establishing sincere collaboration among teachers during Lesson Study is difficult and messy (Adamson & Walker, 2011; Rock & Wilson, 2005). This could be due to teachers' nervousness in opening their classrooms to their colleagues, difficulty in criticising each other and deliberately avoiding any kind of conflicts among themselves (Adamson & Walker, 2011; Fernandez, 2002; Lewis & Hurd, 2011; Rock & Wilson, 2005). However, Kirk and Macdonald (2001) emphasised the importance of establishing a cordial relationship among stakeholders within the education system for successful implementation of curricular innovations. It is possible that teachers working together in Lesson Study may sometimes encounter dilemmas. A study conducted by Rock and Wilson (2005) indicates that Lesson Study participants were not comfortable receiving coaching and constructive lesson criticism from their colleagues, professional experts, and school administrators. This could create conflict and tension among participants during team discussions (Adamson & Walker, 2011). Research points out that unequal power relationships may sometimes exist among teachers, learners, peers, external consultants and Lesson Study participants. This is evident in how lesson observers sometimes over criticize observed teachers' practice (Saito & Atencio, 2013). Such power issues may pose potential threats to the successful implementation of Lesson Study. It is possible that teachers' reluctance to open their classroom to other colleagues for observation, accepting constructive feedback, resistance to changing their sense of professional beliefs, responsibilities and identities are likely to pose a significant threat to Lesson Study practice within and across South African schools.

Another major challenge that may possibly limit the effective practice of Lesson Study is time constraints (Lewis & Hurd, 2011; Yeap, Foo & Soh, 2015). Teachers have different teaching periods and responsibilities, so they tend to struggle with finding a common time to effectively meet, engage in discussions and observe each other's classroom lessons. Though Lesson Study consumes time, it can be very informative if teachers are committed to the practice. One of the pioneers of the Paterson school Lesson Study in New Jersey said:

> …the biggest mistake we can make when pitching Lesson Study is to tell teachers that it is easy and painless. Lesson Study is hard, time-consuming and possibly painful, so teachers should prepare for it. The rewards, however,

> are fantastic, real, concrete and observable improvements occurs in teaching. (Lewis & Hurd, 2011, p.107).

2.5.2 Lesson Study in South Africa

Changing South African teachers' classroom practice from the traditional approach is often complicated by the insubstantial provision of professional development resources and opportunities (Jita, Maree & Ndlalane, 2008). The Japan International Cooperation Agency (JICA) with support from the Provincial Education Authority (PEA) and professionals from the University of Pretoria through the Mpumalanga Secondary School Initiative (MSSI) firstly introduced Lesson Study to South Africa in 1999. According to Ono and Ferreira (2010), the MSSI was designed to enhance the professional knowledge of mathematics and science teachers within the province. The MSSI also aimed at establishing Lesson Study as a school-based professional development programme for teachers as practiced in Japan (Ono & Ferreira, 2010). However, the practice of Lesson Study in South Africa at the national level was not possible at that stage due to factors such as the changes in the curriculum C2005, barring of workshops during school hours and many more (Ono & Ferreira, 2010). Researchers in the education sector are now re-introducing Lesson Study to teachers and schools as a professional development model (Coe et al., 2010; Posthuma, 2012; Stols & Ono, 2016).

A study conducted by Coe (2010) on the practice of Lesson Study as a model for primary school teachers' professional growth in the Western Cape revealed that teachers were able to move learners closer to their Lesson Study goals of making learners better listeners through the introduction of specific instructional strategies. Another study conducted by Posthuma (2012) on the reflective practice of mathematics teachers in the Free State revealed that Lesson Study supports teachers to become better reflective practitioners as they collaboratively strive to enhance learners' conceptual understanding of specific topics. Adopting Lesson Study as a continuous professional development model in South Africa may give teachers the opportunity to be confident and improve their classroom teaching (Coe et al., 2010). This was ascertained when they stated that the peer collaboration phase of Lesson Study could help teachers come out of their isolation and collaborate with their colleagues in a meaningful way. Stols and Ono (2016) developed a manual in South Africa for mathematics teachers on how to successfully implement Lesson Study. In 2017, two lecturers from Naruto University of Education in Japan and the University of Pretoria in South Africa developed Lesson Study as a mobile application for mathematics teachers. The Department of Basic Education regards the use of Lesson Study as district officials' responsibilities towards remedial measures that have been set up to enhance the performance of physical sciences teachers and learners (DBE, 2015). However, many teachers and participants in the current study claim that they have never been exposed to Lesson Study. Therefore, there is a need for Lesson Study to be practiced as a school-based professional development model rather than an educative strategy to be carried out exclusively by district officials. Based on discussions from the reviewed literature, Ebaeguin and Stephens (2014) claim that there are cultural challenges that affect the transfer of Lesson Study into a country's organisational context. It is possible that the practice of Lesson Study may be successfully implemented across South African schools if properly adapted into the country's organisational context rather than practicing it exactly as it is been done in Japan and other countries.

2.6 Theoretical framework

Effective teaching and learning cannot take place without understanding the underlying principles that support science teaching. The theoretical background of this research study is built on the social constructivist learning theory of Vygotsky (1978) and the adult learning theory of Malcolm Knowles (1980).

2.6.1 Constructivism

Constructivism is a combination of several theories and beliefs that give one singular meaning (Amineh & Asl, 2015). The history of constructivism dates back to the time of Socrates who believed that interaction between teachers and learners create opportunities for both participants to interpret and construct knowledge. The underlying assumptions and interpretive epistemological approach of constructivism theory is attributed to contributions like

- Dewey's (1938) description of learning by experience;

- Vygotsky's (1978) description of the zone of proximal development and his demonstration of the impact of language and culture on learners' cognitive development; and

Constructivism is a learning theory applicable to science learning and teaching. In general, this theory has two broad interpretations which are the emancipatory and social constructivism. The interactive nature of this study has therefore urged me to use social constructivism theory, which claims that individuals construct knowledge through collaboration with other people and form meaning based on experience (Von Glasersfeld, 1989; Vygotsky, 1978). This is a school of thought that describes working with other individuals as a vital part of developing learners' logical and conceptual growth through knowledge construction. Nevertheless, studies indicates that knowledge can be constructed in situations where experiences and ideas are discussed, transmitted, debated, explained, reflected upon and tested by individuals in a social environment (Hussain, 2012; Rock & Wilson, 2005). This social exchange amounts to a shared understanding of meaning. Social contructivism validates the objectives that teachers need to engage in tasks that bring about verbal interaction through communication with learners when teaching, which involves active mental processing. Teachers should create learning experiences where learners are given the opportunity to discuss ideas with peers. Vygotsky's brand of constructivism in social learning also states that the accessing of knowledge is a task outlined and adapted into organising an individual's experiences (Ultanir, 2012). Thus, learners should be confronted with challenges that will encourage them to seek, evaluate and measure solutions to given tasks within an environment where they can socially collaborate with peers. Teachers are also to encourage learners to construct knowledge and discover principles within a given task. They are to guide learners to constantly developing their understanding of the subject matter by connecting new ideas to previous experiences or prior knowledge. It can be concluded that the basic tenet of social constructivisim is centered on these two notions:

- An individual constructs understanding of new experiences because of his/her ability to reflect on previous ideas.
- An individual becomes active rather than passive when he/she encounters inconsistency in current understanding, which can be changed to

accommodate new experiences because of interaction with other people (Mrayyan, 2014).

Teaching becomes more effective when teachers engage in activities that promote verbal interaction with colleagues and require that they interpret their scientific knowledge based on previous and new knowledge. Since the Lesson Study process requires teachers as adult learners to collaboratively create meaning and establish a link between their teaching practices, and the learning process using real classroom situations as experimental activities. The principles of social constructivism serves as a foundation on which the Lesson Study approach lies, and it is therefore used as a theoretical framework for this research. This is because social constructivism tends to validate each of the steps involved in the Lesson Study process and this could also help individual to learn in communities of teachers. According to Rock and Wilson (2005), the social constructivist approach provides a guiding framework that underlies the practice of Lesson Study as a professional growth tool designed to enhance teachers' professional knowledge and practice.

2.6.2 Theory of adult learning

As children psychologically begin to grow into adults, their approach to learning changes because they tend to seek knowledge towards personal beliefs. This is because of their different daily experiences, which urge them to achieve self-direction. Knowles (1980) argues that adult education should be significantly different from elementary or secondary education. Knowles (1980, p.43) described adult education with the term "andragogy" when he referred to it as "the art and science of helping adults to learn". Knowles argued that an individual cultivates knowledge differently by possessing different strategies in learning. However, Kearsley (2010) defined andragogy as any form of adult learning. According to Knowles (1980), adults learn based on the following propositions: relevance, experience, self-concept, orientation to learning, readiness to learn and motivation to learn.

- Relevance: Adults want to have a reason for learning, and be informed about the benefits of knowing and the risk of not learning. Furthermore, since adults have control over other aspects of their lives, once they know how learning will occur and what learning will take place they tend to respond positively to learning experiences by directing, setting goals, planning and implementing their own learning activities.

- Self-concept: Adults learn precisely what they think is essential. They become responsible for their decisions thereby taking ownership of learning and move from being a dependent person to become more practical in their approach to learning. Their learning tends to self-direction, self-management of learning and motivation in a dependent context that varies between different learning situations.

- Experience: Adults gather a growing set of experiences that allow them to anticipate a creative resource for learning which is not like that of children since adults' associate experience with who they are. Learning should however, be active, constructive and collaborative since it is associated with existing knowledge and learning activities that are situated in real experience.

- Readiness to learn: Learning should be timely, relevant and focused on useful things in a specific context. Mature people are more interested in taking up courses that have direct relevance to their jobs or personal lives with the aid of support (encouragement) and direction (assistance) in a social context.

- Orientation to learn: Learning is a life-centered activity, which focuses on tasks and problems rather than on subjects. As people mature, their orientation begins to change from the school approach of gathering information for future use to immediate execution of information gathered. This therefore, means that adult learning needs to be problem-centred, contextualised and experiential.

- Motivation to learn: An individual becomes motivated by various factors but in adults, most motivations are intrinsic such as self-satisfaction, enjoyment, having control of what is learned, feeling that what is learned is worthwhile and satisfaction with accomplishment.

The following principles support the application of andragogy theory in professional development programmes to becoming more effective for teachers.

- It must involve adult learners who are willing and ready to participate.
- The programme must be relevant to teachers' lives and have immediate usefulness to the teachers' practice.
- The programme presentation must involve active and lifelong learning focused on ways of solving classroom problems.
- Such programmes must consider participants' experiences and provide opportunities for participants to share knowledge with one another.

The effect of these principles on adult learning is depicted in Figure 2.2.

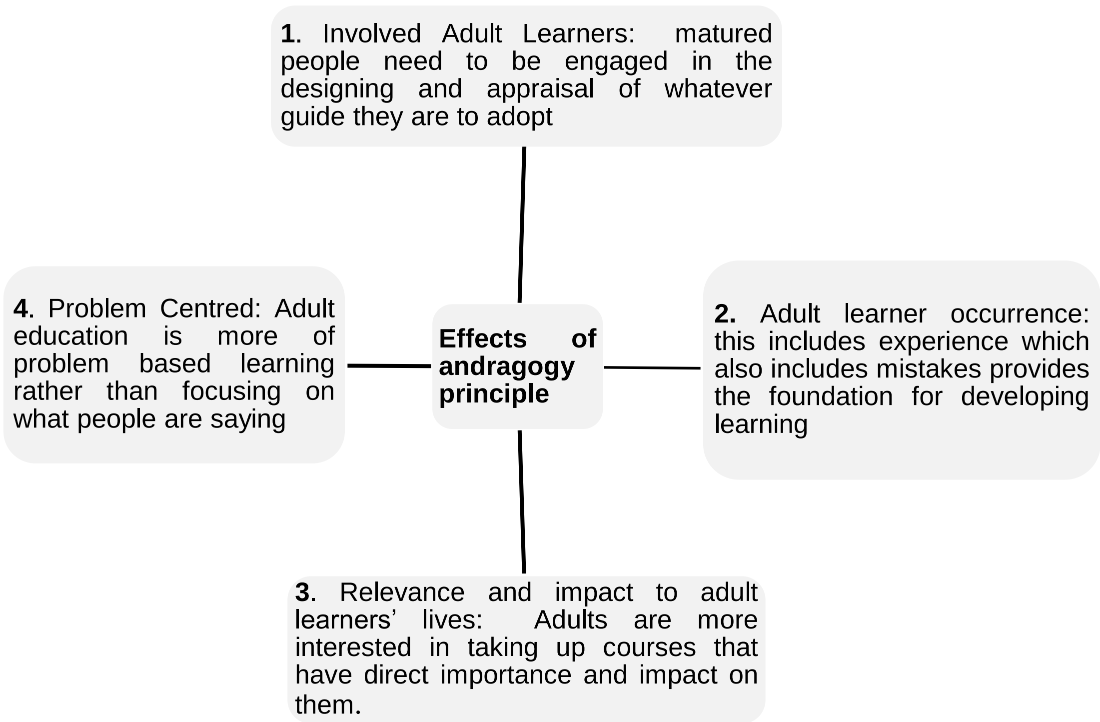


Figure 2-2: Principles of andragogy guiding effective professional development, adapted from Kearsley(2010).

For this study, Knowles' assumptions as a framework for improving teachers' practice was considered. The use of teachers' experience, application of the self-concept, evaluation of classroom instruction and teachers' orientation to improve classroom practice allows the theory of adult learning to form a theoretical basis for the professional development of physical sciences teachers in this study. All these aspects are deep-seated within the Lesson Study approach. The andragogy theory was also used as a fundamental framework for exploring factors that might affect teachers effective and continuous participation in professional development programmes in this study.

2.6.3 Conceptual framework.

The focus of the study is to understand participants' ideas and behaviour when teaching electricity and magnetism during a Lesson Study intervention. The conceptual framework (Figure 2.3) proceeds from the amalgamation of the theoretical framework (social constructivism and adult learning theory), relevant Lesson Study concepts proposed by Lewis and Hurd (2011), and reviewed literatures that explored the effects of Lesson Study on teachers' professional knowledge (Jones & Straker, 2006; Shulman, 1987; Tamir, 1988; Zeidler, 2002) in Section 2.4.2.2.

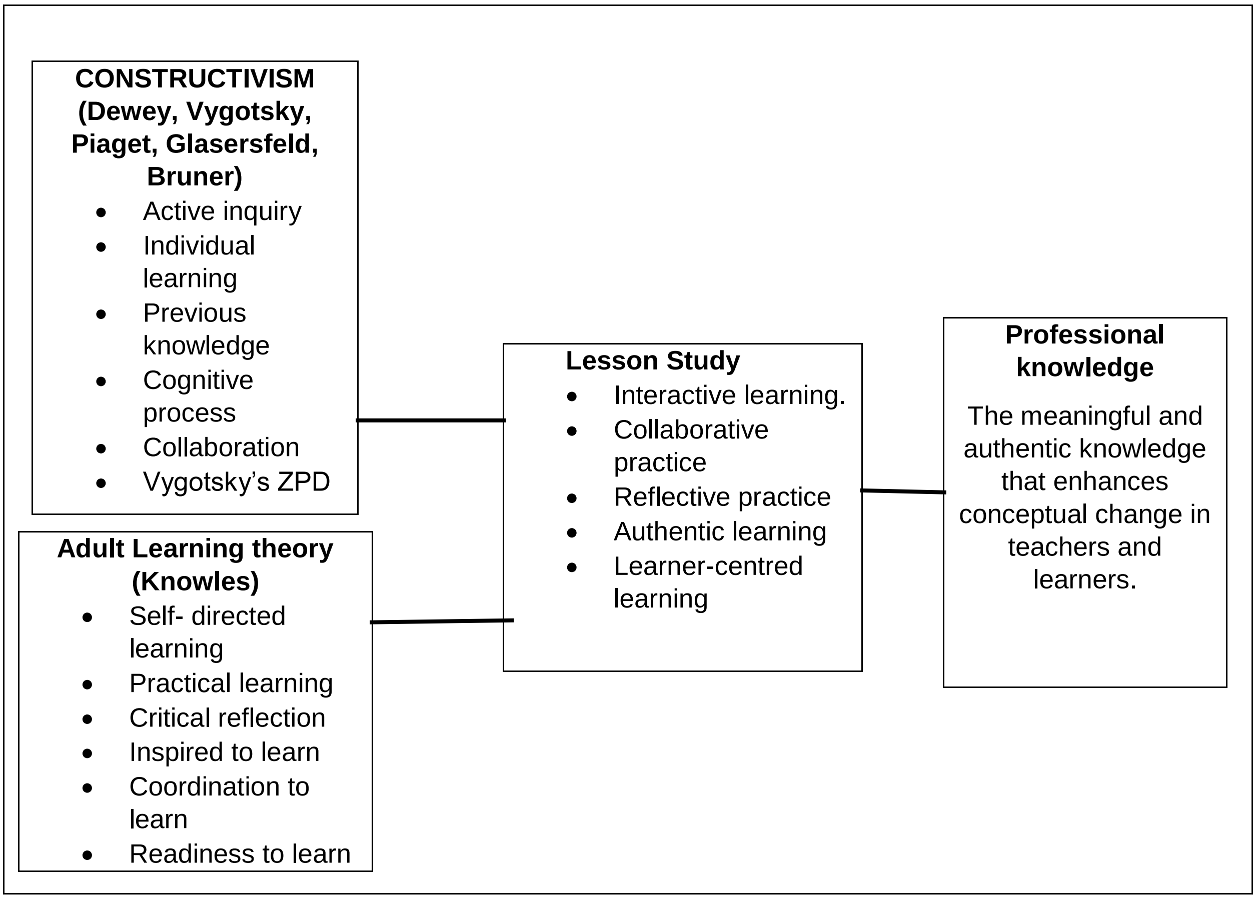


Figure 2-3: Framework for Lesson Study as teacher professional development.

In this visual representation, it is recognised that the constructivist view of learning is well-suited to the view of self-direction since it highlights the mutual features of active inquiry and individual learning. The relevance of constructivist theory in this framework lies in individual teachers attempt to construct knowledge on how to improve teaching during the collaborative practice of the Lesson Study process. This collaborative practice could create opportunities for teac hers to build a community of practice where they are able to learn from each other. Vygotsky's zone of proximal development is used in an attempt to develop teachers' knowledge (subject matter and pedagogical content) and skills through collaborative Lesson Study activities. Tasks and challenges given to teachers during the intervention may be slightly different from their present level of cognition but within the ZPD. The ability to successfully complete such difficult tasks could increase individuals' confidence and motivation to undertake more complicated challenges during their classroom teaching. This describes how cognitive growth occurs in individual teachers as they develop their knowledge and effectiveness based on their sociocultural environment and interaction with others during Lesson Study intervention (Warford, 2011; Vygotsky, 1978). If teachers (adult learners) can construct knowledge from Lesson Study activities, they should be in a position to prepare practical instructions that develop learners' knowledge construction, problem-solving skills and improve learners' conceptual understanding.

Several researchers have emphasised the importance of adult learning theory in professional development (Bedi, 2004; Brookfield,1995; Kearsely, 2010; Motlhabane & Dichaba, 2013). Brookfield (1995) highlighted self-directed learning, practical learning, critical reflection and learning to learn as the four main research areas on adult learning processes. The self-direct learning could allow teachers (adult learners) to be in control of their own learning process, as they become actively involved in planning lesson objectives aimed at addressing learners' difficulties in electricity and magnetism. The concept of practical learning as indicated in the framework is essential to the development of teachers' knowledge and skills. This could involve the use of teachers' experiences and reflection on learners' challenges to develop practical skills that may enhance learners' conceptual understanding. It is possible that Brookfield's view on learning to learn comprises teachers' readiness, coordination, and inspiration to learn. Bedi (2004) argued that appreciating the learning style of an individual in a given situation helps teachers to better understand their learners. He said:

> …*an understanding of andragogy has fundamentally changed me as a teacher because it has informed my teaching methods and expanded and harnessed my teaching skills. I would argue that there is a natural bridge between my expanding knowledge of learning styles and the way in which I have matured as an andragogical educator* (Bedi, 2004, p. 93).

Andragogy explains how Lesson Study can help teachers to understand their learners' actions and to motivate learners to explore various options to solve a problem and to become self-directed learners. Teachers' willingness to engage in this Lesson Study intervention could inspire them to become lifelong learners seeking to improve their professional knowledge, skills, and classroom practice.

Since the research strategy is pertaining to teachers' experience in physical sciences classrooms and readiness to change their practice, it is possible that participating in this Lesson Study research may give teachers the opportunity to improve their knowledge base and create opportunities for self-directed, experiential and transformative learning. It could also help the teachers to explore ways of improving their classroom teaching practices as they develop their learners' scientific and thinking skills.

2.1 Conclusion

It is clear from the literature that electricity and magnetism is one of the difficult topics in physical sciences. It is necessary for teachers to grasp the important content ideas when teaching electricity and magnetism since the topic is included in the science curriculum at the different grade levels. This chapter also explored international and national perspectives on the professional development needs of physical sciences teachers. There is a clear indication that the teaching and learning of physical sciences should involve interactive and experimental practice due to the emergence of drastic technological transformation in this modern era. Lesson Study offers a model that contains interactive and experimental practice as part of the characteristics considered for active professional training programmes. In addition, the Lesson Study model equally supports demands made on teachers to improve their classroom practice through collaborative and reflective inquiry. It is clear that the Lesson Study model is not developed to polish teachers' skills but rather to improve teachers' knowledge and practice (Lewis & Hurd, 2011). The reviewed literature also indicates that the Lesson Study process can improve teachers' reflective practice, receptivity to feedback from colleagues, ability to design relevant instructions and learners' assessment, involvement in a culture of professional inquiry and learners' learning. Finally, the social constructivist theory and adult learning theory as a theoretical framework that inspired the use of Lesson Study was referenced in this research work. The literature to conceptualise how sampled teachers can use the Lesson Study process to enhance the teaching of electricity and magnetism was utilised. However, Figure 2.3 explains the process of using Lesson Study to achieve instructional change among teachers, through the articulation of constructivist and adult learning philosophies. Chapter 3 provides a detailed discussion of the research design guiding this study.

3. CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This chapter explains the research methodology adopted in this study. The research design for this study is discussed considering the statement of purpose as indicated in Chapter 1 to understand participants' ideas and behaviour towards the teaching of electricity and magnetism during a Lesson Study intervention. The research problem required a qualitative approach, with a case study design within the interpretive paradigm. The research paradigm, research design, sampling method, data gathering procedures, data analysis strategies, quality assurance criteria, ethical considerations and limitations of the study are discussed in this chapter.

3.2 Research paradigm

A research paradigm is an established principle designed around a basic truth, which gives rise to a specific worldview (Nieuwenhuis, 2014). Since this study aimed to understand participants' ideas and behaviour when teaching electricity and magnetism during a Lesson Study intervention, the interpretive paradigm was chosen for this study. According to Creswell (2003), interpretivism assumes that reality is created due to the multiple interpretations that individuals establish socially and we cannot separate ourselves from what we know. In this study, participants shared their subjective experiences about the reality of Lesson Study. Participants' opinions were later viewed to enable a better understanding of the process of change in teachers' knowledge and classroom practices in this Lesson Study intervention. Cohen, Manion and Morrison (2007) claim that the meaning participants give to their experiences is better understood when words and actions of participants are taken into consideration. The interpretive paradigm allowed me to listen to what teachers had to say about their Lesson Study experience and observe teachers' Lesson Study meetings and classroom lessons.

In explaining my paradigmatic standpoint as a qualitative researcher, the researcher is aware that the research study needed to be guided by basic philosophical positions (Maxwell, 2013). In this section, I discuss how my philosophical beliefs provide a unifying framework of understanding knowledge about reality (ontology), my search for knowledge about truth (epistemology) and my approach to acquiring this knowledge.

3.2.1 Ontological assumption

Ontology is described as the study of nature and it's form of reality (Nieuwenhuis, 2014). Having taught physics for five years as a teacher, I assume that reality is subjectively constructed based on teachers' interaction with the natural and social world (within the context of a professional group, community, school or classroom) and of understanding such worlds. This research, therefore, follows a qualitative approach which assumes that participants construct their own subjective meaning about reality and truth, make sense of their social experiences and interpret the socially constructed knowledge within the Lesson Study context (Creswell, 2003; Nieuwenhuis, 2014). In my search to understand how participants construct personal realities based on their experiences, I had a one on one interaction with the participants. This enabled me to seek different views and opinions about teachers' subjective experiences of discussion and reflection, and how they shared their experiences with one another. However, depending on what participants have in mind, it was assumed that careful interpretations of participants' experiences and reflections can give an insight into how participants create multiple realities during this Lesson Study intervention (Creswell, 2003).

3.2.2 Epistemological assumption

According to Nieuwenhuis (2014, p.55), "Epistemology looks at how one knows reality, the method for knowing the nature of reality, or how one comes to know reality - it assumes a relationship between the knower and the known". Seeking knowledge deals with finding the truth and understanding the phenomenon that is being studied, as well as understanding what works best in a specific situation (Creswell, 2003). However, epistemological reflection affirms that people create meaning of a phenomenon based on their specific social, economic, political and cultural experiences (Nieuwenhuis, 2014). In my search for in-depth understanding of teachers' inner worlds, I related closely with the participants on a personal level through interviews, observation of Lesson Study sessions and participants' classroom teachings, and document analysis of participants existing lesson plans. Each participant constructed their personal views of their Lesson Study experiences and practice. This enabled me to understand how Lesson Study intervention influences teachers' knowledge and classroom practice in teaching electricity and magnetism.

3.3 **Research design**

Yin (1994, p.19) describes a research design as a "work plan for getting from here to there, where here may be defined as the initial set of questions to be answered, and there is some set of conclusions (answers) about these questions". However, a research design could be directed by the idea of "fitness for purpose" (Cohen et al., 2007, p.78). Hence, the research design of this study should be suitable to understand participants' ideas and behaviour when teaching electricity and magnetism during a Lesson Study intervention.

Therefore, a qualitative inquiry using an exploratory case study design was adopted in this study. Yin (1994) describes a case study as a practical inquiry that explores a case or an event in its real environment, particularly when boundaries between the case or event and environment are not obvious. In other words, clear evidence is needed in this study, to explain the process of change in teachers' knowledge and classroom practice during this Lesson Study intervention. Cohen et al. (2007, p.254) claim that a case study "portrays what it is like to capture the reality of participants' thoughts, feelings and lived experiences about a phenomenon in its real-life context". Capturing participants' views in this study provided an opportunity to analyse participants' words and actions from multiple perspectives. However, two case studies of the Lesson Study intervention were separately carried out in this study due to logistical challenges. One pair was located in a rural environment while the other pair was from an urban setting. The two case studies provided a detailed understanding of the effects of the Lesson Study intervention on the teaching of electricity and magnetism in different classroom situations. However, there was no interaction between the two pairs.

Each Lesson Study pair explored three different research lessons. For each of these research lessons, only one Lesson Study cycle was conducted, since it was not possible for teachers to re-teach the revised lesson due to scheduled school programmes, teachers' workload and curriculum time constraints. Instead, reflection on the research lessons was used to provide generic guidelines in planning and teaching the following research lessons. Also, teachers would be able to use the revised plans for the next academic year. The Lesson Study sequence was adapted as re-teaching was not an option. Each Lesson Study pair collaboratively planned lessons by setting goals and objectives to be achieved when teaching various concepts. The Lesson Study planning sessions each lasted for about sixty to ninety minutes. All teachers taught the planned lessons in their classrooms and each lesson presentation was video recorded. The teachers met after each lesson to collectively view the recordings with the aim to reflect, analyse and discuss the learners' learning, and teachers' teaching during these lessons. Outcomes from the debriefing section were used to improve the planning and teaching of the next lesson.

Cohen et al. (2007) claim that case studies use participant observation techniques. So, the researcher's role in this study was that of a participant observer, because I was able to immerse myself in each phase of the Lesson Study process through talking with the participants, observing their actions when responding to questions, and observing their classroom teachings and attitude towards learners' learning. This assisted the researcher to acquire a thorough understanding of participants' mastery of subject matter, demonstration of content and pedagogical knowledge, teaching behaviours, reflections and perceptions about learners' difficulties in electricity and magnetism. Nieuwenhuis (2014) claims that participant observation allows researchers to have an insider perspective of the phenomenon being studied. The resarcher's close relationship with the participants provided an opportunity to understand how they planned, taught, and reflected on their lessons and how they made meaning of the Lesson Study program. This fits in with the assumption that members within a particular study population may have different perceptions about a programme and their perceptions may be influenced by certain assumptions. The researcher strived to maintain her position as an observer to enable the collection of rich and thick data since the Lesson Study pairs were cognizant of the observation activities. Each pair participated for a period of five weeks in the Lesson Study activities. Pair A taught Grade 11 during the third term and pair B taught Grade 10 during the second term. A diagrammatic representation of the teachers' activities designed for this study is shown in Figure 3.1.

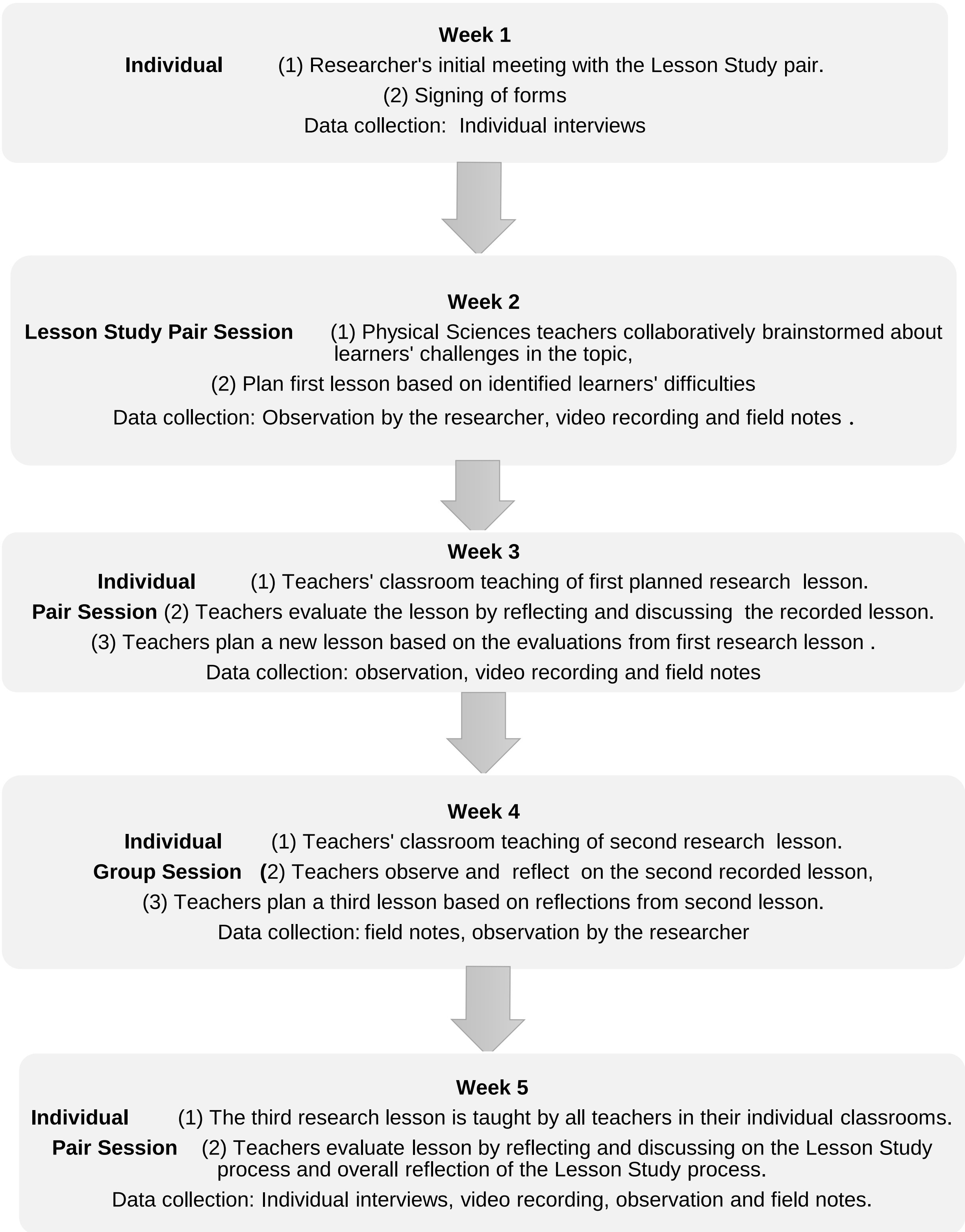


Figure 3-1: A diagrammatic representation of activities conducted during the Lesson Study intervention.

3.4 Sampling method

Sampling in a qualitative study emphasises the uniqueness and exclusive distinctiveness of a group of people or individuals in question (Cohen et al., 2007). The participants represent nothing or nobody else but themselves. Case studies use purposive sampling for the recognition and collection of information that is rich in cases related and specific to the investigator's personal needs or interest (Cohen et al., 2007; Merriam, 1998). More so, studies using purposive sampling help researchers to select participants who have comprehensive knowledge of the problem being explored, allows judgmental decision and reason for using a specific category of participants, provides greater in-depth findings than probability sampling techniques and it fits well when studying individual cases (Cohen et al., 2007; Maree & Pietersen, 2014; Merriam, 1998). Also, participants have to be willing to participate in research. Therefore, purposive and convenient sampling was employed in this study to capture specific attributes of sampled teachers, knowing that it does not represent the whole population of physical sciences teachers in South Africa (Cohen at al., 2007; Maxwell, 2013). However, participants were expected to have a minimum of two years teaching experience in physical sciences.

According to Creswell (2013), qualitative research involves collecting extensive details about a few participants. He claimed that the required sample size for qualitative research studies should not be more than four to five participants using a case study approach. More so, Dudley (2014) claims that Lesson Study is characterised by its small sample size of two to five teachers within a group, confined to study events that take place during the teaching and learning process, with the purpose of improving their classroom practices. A total of sixteen schools were approached since it was initially planned to engage eight physical sciences teachers teaching the same grade level in one cluster. However, only four teachers from three schools agreed to engage in the study because of the nature and sensitiveness of the study. The four teachers were unable to function in one cluster due to logistical reasons. Two of the teachers were Grade 11 teachers from a rural school, while the other two were Grade 10 teachers from city schools. Therefore, the original plan was adapted and it was decided to work with two Lesson Study pairs as two independent cases. The Grade

11 Lesson Study pair participated in the third term (July to September) 2016 while the Grade 10 Lesson Study pair participated in the second term (April to June) 2017. This was an advantage to the researcher since it would have been impossible to observe both pairs in the same term. This small sample size allowed small group discussions and close interaction among the participants. This implies that findings from this study should not be generalised. However, results from this study provided the justification needed to develop logical generalisation from the sample that was studied based on rich and in-depth evidence obtained. Pseudonyms have been used to present the four teachers that agreed to take part in the study. The Grade 11 Lesson Study pair consists of Mbali and Lenox from the rural school, while the Grade 10 Lesson Study pair consists of Alex and Martha from the urban schools.

Permission to access schools was obtained from the Department of Education. Different schools were contacted and permission to meet possible participants was obtained from the principals. A meeting was scheduled at each school between the principal, teacher(s) and researcher to discuss teacher(s) participation in the study. Letters containing information on the study were given to school principals and physical sciences teachers who all signed informed consent to participate in the study. Learners, parents, and guardians of learners were also informed about the study. All communication processes and arrangements were made directly with the participants after obtaining permission from their respective school principals.

3.5 Data collection

3.5.1 Data collection method

The collection of data is an extremely significant section of any research. Instrumentation refers to the tools that researchers employ to measure variables of interest in the data collection process and it also helps researchers to keep track of what is observed and how to report it (Hsu & Sandford, 2010). A qualitative case study uses multiple sources and instruments to gather in-depth knowledge of an event, in a way that encourages convergent lines of inquiry (Nieuwenhuis, 2014; Small & Uttal, 2005; Yin, 1994). The data obtained in this study was collected through multiple sources which include semi-structured interviews, observations of classroom teaching and Lesson Study sessions, field notes, narrative accounts, document analysis of participants' initial lesson plans and their reflective writings (Cohen et al., 2007). These data sources contain rich and thick descriptions of processes occurring in the adapted scenario, and they are well grounded and aligned with the interpretive mode of data collection (Cohen et al., 2007; Merriam,1998). The interview questions and observation guide used in this study were developed from the literature and discussion with supervisors. The relationship between the research questions and the instrumentation is represented in Table 3.1, followed by a discussion on the data gathering techniques used in this study.

Table 3-1*:* ***Relationship between the research questions and instrumentation***

Main research question: How does the Lesson Study process affect the teaching of electricity and magnetism?		
Research sub questions	**Data collection technique**	**Aim**
How does Lesson Study influence teachers' knowledge about teaching electricity and magnetism?	Interview, Observation, Document analysis (teachers' reflective writing), Fieldnotes	To understand how the process of collaborating together during Lesson Study have influenced teachers' professional knowledge.
How does Lesson Study influence teachers' attitudes and beliefs towards teaching electricity and magnetism?	Interview, Observation Document analysis (teachers' reflective writing), Fieldnotes.	To explore how the different stages of the Lesson Study cycle change teachers' perceptions, beliefs, and experiences about their classroom practice when teaching ele ctricity and magnetism.
What are the contextual factors affecting teachers' participation in the Lesson Study process?	Interview, Observations, Field notes	To find out other probable factors that might affect teachers' effective participation and continuous practice of Lesson Study.

3.5.1.1 Semi-structured Interviews

An interview is a two – way dialogue between two or more individuals on a topic of common interest. It allows the interviewers to gather data, discuss, interpret and learn about participants' behaviours, ideas, beliefs and opinions (Nieuwenhuis, 2014). Interviews were used in this study to freely access individual teachers' views about learners' challenges in electricity and magnetism and teachers' opinions about Lesson Study. The use of interviews in this study also assisted in obtaining rich descriptive data while trying to comprehend how participants construct knowledge socially and in a classroom situation. The interviews were successfully managed using effective communication skills such as listening attentively, pausing and probing to obtain responses to deep and complex issues (Ritchie, Lewis, Nicholls & Ormston 2014). These communication skills were kept in mind when interviewing the participants in the study. A first interview (see Appendix 9) was conducted with each of the participants before commencing the research. The questions were used as a guide to explore in-depth information about teachers' challenges in teaching, knowledge of learners' understanding, attitude towards teaching specific concepts and classroom method used in enhancing learners' conceptual understanding of electricity and magnetism. The predetermined questions were used and followed up to probe deep into participants' responses and clarify any misunderstanding from what was said.

A second interview was conducted with each participant after completing the Lesson Study cycle to probe their understanding, experiences, challenges and expectations about the Lesson Study processes. Each interview lasted fifty to sixty minutes. Interviews were audio-recorded, transcribed and coded based on each participant's response for data analysis purposes. These interviews were conducted during individual participants scheduled appointment dates and the sequence of the questions was determined by the investigator's ability to probe every statement made by the participants. The interviews were continued until participants' responses and information became saturated from the investigator's perspective. A clarification of the nature of the interviews is provided in Table 3.2

Table 3-2*: Clarification of the nature of the interview*

INTERVIEW 1 Conducted prior to Lesson Study meetings and classroom observations.	**PURPOSE OF INTERVIEW 1** • To explore teachers' knowledge (awareness and knowledge) of teaching electricity and magnetism. • To understand how teachers address difficulties in electricity and magnetism?
INTERVIEW 2 Conducted at the end of data collection process.	**PURPOSE OF INTERVIEW 2** • To probe teachers understanding, experiences, challenges and expectations about the Lesson Study process. • To understand how the practice of Lesson Study has helped the teachers in addressing difficulties in electricity and magnetism. • To explore possible factors that might affect teachers' continued practice of the Lesson Study process.

3.5.1.2 Observations

Observation is a systematic data gathering approach which allows researchers to use all senses in examining real classroom situations as experienced by participants in their natural environment (Nieuwenhuis, 2014). The researcher's role in this study as a participant observer enabled her to gather more information on why and how selected teachers' knowledge and classroom practice in teaching electricity and magnetism within the Lesson Study context develops. This also enabled her to have an interaction with the participants without influencing any of the Lesson Study activities. The researcher was able to conduct unbiased observation and gather in-depth information about the participants since she strived to play a neutral role of an observer. Participation in this study as the investigator assisted in building a cordial relationship with the sampled teachers and become naturally accepted by them. It also helped the researcher to gain an insider's understanding and first-hand experience of how these teachers reflect, discuss and support learners' understanding of electricity and magnetism in their classroom within the Lesson Study context.

Each Lesson Study pair was observed during the lesson planning phases, teaching phases and during the discussion and reflection phases. The teaching sessions were video recorded and viewed by participants in the study pair after the lesson to determine if planned learning goals were achieved. The researcher also made field notes while observing the participants as they jointly planned, discussed and reflected on lessons taught.

The classroom observations were carried out during teachers' actual teaching periods while the planning and discussion observation were carried out after school. Each classroom observation lasted for the duration of the normal period allocated to each school's lesson which was ranging from forty to ninety minutes. The two teachers in each Lesson Study pair were observed individually by the researcher in the classroom while teaching the planned research lessons to learners. The teachers classroom observation schedule was categorised under assessing learners' learning, instructional delivery, classroom interaction and teachers' knowledge. Protocol of the classroom lesson observation is provided in Appendix 11.

During the Lesson Study meetings, participants watched the recorded videos after their classroom teaching. While observing the recorded videos, participants were given the observation checklist to enable them to reflect on identified classroom elements, as they documented observed responses of learners during the lesson presentation. The Lesson Study pair observation protocol is provided in Appendix 10.

3.5.1.3 Document analysis

Bowen (2009, p. 27) describes documents as materials that "contain text (words) and images that have been recorded without a researcher's intervention". Bowen holds that document collection is a particularly good source of data in qualitative case studies since it gives a rich description of a single phenomenon and allows the investigator to have a better understanding about what is being studied. The documents collected for this study include individual teachers' lesson plans, investigator's field notes, and participants' reflective journals.

Lesson plans are historical documents and resources that provide reflective evidence of teaching philosophy and anticipated activities in the classroom (Jensen, 2001). Individual participant's lesson plans were collected before the commencement of the intervention to assess teachers' content and pedagogical knowledge about teaching electricity and magnetism before the Lesson Study intervention. The lesson plans also helped to understand how the participating teachers plan objectives and activities, choose resources used for teaching and present and support main ideas to learners. The joint lesson plans developed by the Lesson Study pairs were also collected and analysed with the aim of understanding how the teachers collaboratively plan, reflect, discuss and address learners' difficulties related to electricity and magnetism.

Field notes are researchers' documented interpretations of unfolding events within a qualitative research study. They are generated by the investigator and used as means of the data source in a study. Field notes were taken throughout the study from the individual interview section to the final implementation section where reflective writings and recorded observations were discussed. The objective of the field notes in this study was to complement the Lesson Study pairs' planning and reflective notes, take down notes that could be supportive of or in contrast with participants' reflective writings and to pinpoint changes that participants made in their instructional practice. Additional field notes were taken when viewing the first and second cycle of recorded lessons, to ascertain the effect of the model on participants' classroom practice. All informal conversations, records of what the researcher heard and saw (observed) during the study, as well as her thoughts and experiences during the lesson were also recorded in the field notes.

Brookfield (1995) argues that the use of reflective documents has become a custom in the professional training of teachers. Boud, Keogh, and Walker (1987) described reflective writings as scripted documents in the form of notebooks, diaries or pieces of papers that are used when putting down thoughts and experiences in writing. Reflective writing can be used by people to recapture their experiences during a programme or event, with the aim of informing new teaching and learning processes (Boud et al.,1987). Within the context of this study, participants were requested to put down their reflections in writing for self-evaluation and self-observation purposes. These reflections contained information about their experiences, immediate thoughts, challenges, achievements and successes encountered before, during and after the different phases of the Lesson Study model. The researcher also wrote down her reflections about unanticipated experiences that occurred when conducting the study. The participants' reflective writings were collected after the Lesson Study cycle and used alongside with the researcher's field notes to clarify issues encountered during the study. These documents assisted the researcher in gaining insight into physical sciences teachers experiences on how they reflected, discussed and enhanced learners' conceptual understanding when teaching electricity and magnetism. The researcher continuously sought information from the participants in order to address noticeable gaps in their responses and also reflected back on her field notes to confirm her conclusions. The document analysis was conducted according to the document analysis guideline provided in Appendix 12.

3.5.2 Data gathering procedures

At the preparation phase, the pair of teachers planned their first research lesson by setting learning goals, designing the teaching and learning method to be used and the procedure to assess learners' learning when the research lesson is taught. The pair of teachers deliberated on the difficulties that learners from previous years' experienced with these topics. They also reflected on the different teaching methods that they have used in teaching the topics in the past and collectively considered ways of addressing learners' difficulties. Problem-solving activities and demonstration activities were also included in the planning of research lessons. During the teaching phase of the Lesson Study cycle, the jointly prepared lesson was later taught by both participants in their classrooms. Differing from the Japanes model, the participants were unable to observe each other during the teaching phase due to their different teaching periods. More so, meeting the objectives of the curriculum requires teachers to work at a pace which does not allow them to be absent from class. Therfore, the lessons were video recorded from the rear of the classroom and these recordings were played back during the discussion and reflection phase. It enabled participants to discuss whether the learning goals were achieved, based on the designed assessment and the lesson planned. The focus of their discussion was not only on the teachers' teaching but also on the learners' understanding of the difficult concepts that were taught. This was done to improve their individual classroom instruction and next lesson plan. An illustration of the Lesson Study cycle used for the research lessons is shown in Figures 3.2 and 3.3 respectively.

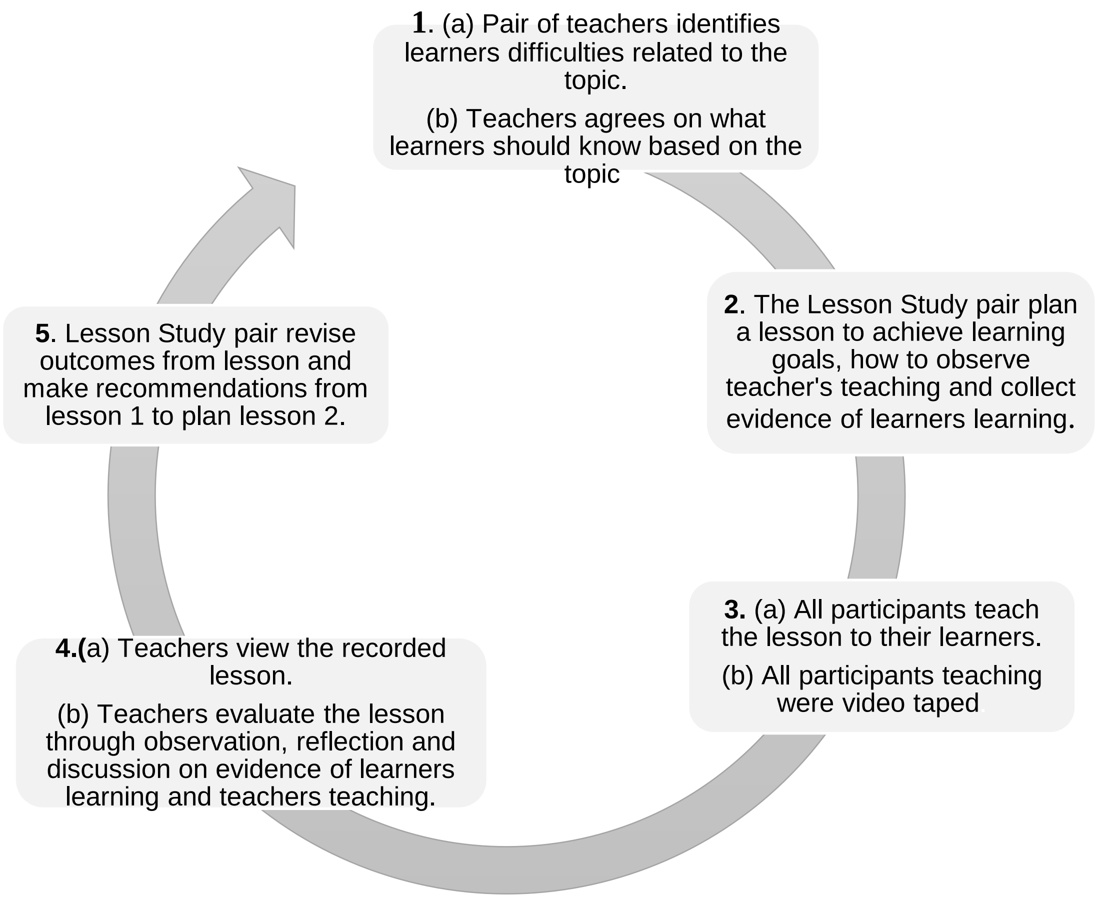


Figure 3-2: Illustration of the Lesson Study cycle for the first research lesson

Figure 3.2 shows the continuous process of the first Lesson Study cycle adapted for this research. This cycle involves the preparation, teaching, observation, discussion and reflection phases. The current study involved three Lesson Study cycles of three different topics. The first cycle (Figure 3.2) involved the planning of a Grade 11 lesson on magnetic field associated with current for pair A and Grade 10 lessons on magnetic field lines for pair B. This was followed by the teaching activity and collection of information based on learners' learning and teachers' teaching by the Lesson Study pair. The next stage was the discussion and reflection phase where the pair of teachers viewed the recorded teaching, observed, analysed, discussed and reflected on the learners' understanding of the topics taught. Teachers identified teaching and learning gaps based on their reflections, revised their outcomes and generated recommendations which were used to plan a new lesson.

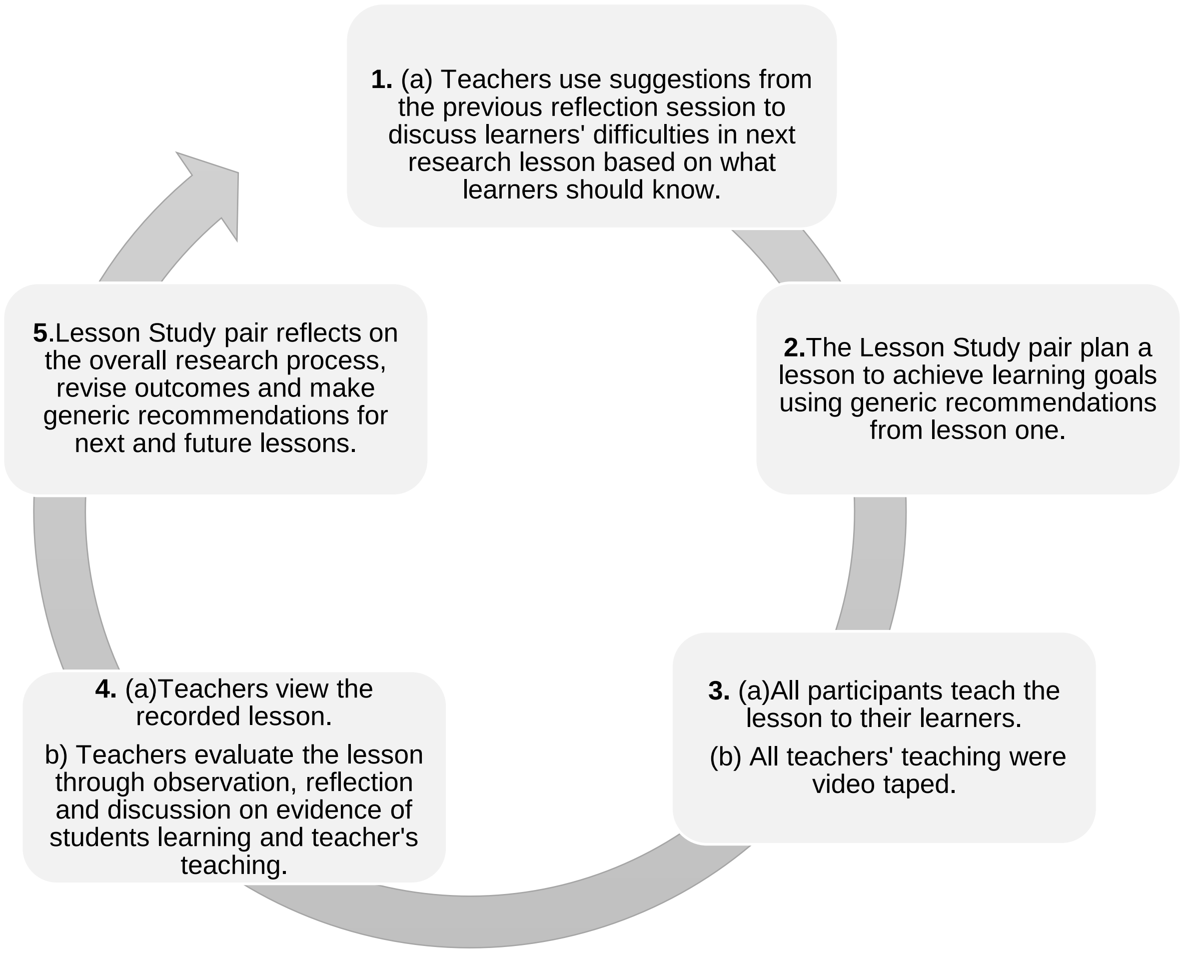


Figure 3-3: Illustration of the successive Lesson Study cycle for second and third research lessons.

The Lesson Study cycle shown in Figure 3.3 involves the application of generic recommendations from the previous lesson and to plan another Grade 11 lesson on Faraday's law of electromagnetic induction and Grade 10 lesson on the earth's magnetic field. This new lesson was taught by the respective teachers to the same classes as before and videotaped. Teachers collectively viewed the recorded lesson and reflected on the evidence of learners' learning. They compared the teaching and learning improvements between lesson one and lesson two. The outcomes were aligned with the learning goals to determine if the outlined objectives were achieved. Similarly, a third cycle was conducted as teachers used recommendations from the first and second lessons to plan another lesson on electric circuits for both Grade 10 and 11 learners. After the third Lesson Study cycle, participants (teachers) engaged in a final reflection on the whole Lesson Study process with the aim to share their experiences and improve future lessons. At the conclusion of the Lesson Study intervention, participants shared their experiences with the researcher during the final interview.

The researcher, as the primary investigator, tried to understand the impact of the Lesson Study model on participants' practices as an insider while inevitably remaining an outsider to the research under study. Taking a reflective position about the success of the study as a primary investigator allowed the researcher to interpret her own perception of the model and participants under study. The researcher was also able to evaluate reports given by participants during interviews since people's behaviour is sometimes contradicting to reports about their actions and beliefs.

A timeline of the data collection process for Lesson Study pair A is provided in Chapter 4 while that of Lesson Study pair B is provided in Chapter 5

3.6 **Data analysis**

According to Cohen et al. (2007), qualitative data analysis is a process of making sense of data obtained through participants' interpretations of the phenomenon under study in the form of categories, patterns, and themes. Qualitative data analysis follows the principle of "fitness for purpose" and it is heavily based on interpretation (Cohen et al., 2007, p.501). Qualitative data analysis is a non-linear and ongoing procedure which continuously links data collection, processing, analysis, and reporting together (Nieuwenhuis, 2014). In qualitative data analysis, the goal of the researcher is to "summarize what was heard or seen in terms of common words, phrases, themes or patterns to aid the researcher's understanding and interpretation of that which is emerging" (Nieuwenhuis, 2014, p.100). Nevertheless, studies claim that understanding the foundation of the research problem, statement of purpose, research questions and theoretical framework in a study, can be used as a systematic and iterative approach in designing a research framework method to manage and analyse qualitative data (Gale, Heath, Cameron, Rashid, & Redwood, 2013; Latham, 2014). In order to understand and interpret participants responses as data for the study, the researcher adequately categorised participants words and actions in form of codes emerging from data and a-priori codes identified from the literature, keeping the research questions for the study in mind.

The data obtained in this study were analysed using content analysis. Nieuwenhuis (2014) describes content analysis as an iterative and inductive process which uses the similarities and differences in the text to support or disconfirm claims about the phenomenon being studied. The content of data obtained in this study assisted in establishing how participants made meaning of the Lesson Study model, through analysing their attitudes, experiences, knowledge, and opinions to understand their comprehension of the model. The recorded observations were also repeatedly viewed and supported by the recorded field notes to explore the effect of the Lesson Study process on participants' beliefs and practice. This also helped to avoid biased interpretations with findings and to complete the analysis. Evidence of participants' responses that is relevant to this study is presented in quotes (Anderson, 2010).

3.6.1 Data transcription

Interviews for this study were transcribed word for word as originally used by the participants. During the data analysis process, the researcher made sure that the data was not interpreted prematurely. All hand-written notes and transcribed videos of lessons observation were typed out on the same day after the observation to enable the researcher to recall other incidents that occurred outside the recording and clarify her own scribbled notes. The researcher repeatedly listened to the audio recordings of the interviews and watched the videos of the lessons to enable her to understand and interpret what emerged from the data. In situations where clarification was needed, the researcher went back to the participants during the next meeting to clarify misunderstandings and interpretations needed in the collected data. All field notes and transcribed data were then carefully read to ensure that the transcripts gave a true account of participants' actual interview statements and the lesson observation. Table 3.3 portrays a part of the table created during the analysis of one of the participant's interview transcription.

Table 3-3: Part of a table created during the analysis of one of the participant's interview transcription.

Researchers' comments	Interview	Codes
It seemed Lenox believes that learners don't have a problem in specific topics since they are not assessed at the matric level, electromagnetism is not considered difficult.	**Researcher:** In your practice as a physical sciences teacher, what can you say about learners' difficulties and misconceptions in electricity and magnetism? **Interviewee:** To those of us marking, we believe that learners have a problem with Energy theorem and electricity. Although electricity, or electric circuits as they call it, is very simple but learners still find the topic difficult. Your question is pertaining to electromagnetism. When we moderate for marking, we hardly consider electromagnetism as a difficult topic because learners are not assessed on that topic at the matric level.	Teacher's belief on learners learning difficulties; Teacher's perception about electricity Teacher's attitude towards electromagnetism; No learners' assessment at matric level.
Lenox's response indicates that he uses more direct instruction and solved examples in addressing his learners' difficulties since they lack resources for practical activities.	**Researcher:** How do you address the difficulties and misconceptions that learners have in electricity and magnetism? **Interviewee:** In an electrical circuit, I do tell them to first take up the parallel arrangement, solve it then put it back in the circuit diagram to calculate the series circuit. For electromagnetism, I try as much as possible to do practical activities whenever apparatus is available and I encourage them to carry it out individually. Above all, I will say I use quite a numerous example to address their difficulties.	Giving specific instruction Expectation from learners; Practical activities Use of several worked examples

3.6.2 Data coding

Codes are used to label, compile and organise data obtained in a study. Stuckey (2015) claims that the coding process used in qualitative analysis takes time and creativity. He outlined three major steps which were kept in mind during the coding process of the study. The steps include repeated reading through the data and creating a storyline, categorising the data into codes, and using memos for clarification and interpretation. These steps were critically considered when the coding process for the data was started. Data obtained for this study was manually and logically coded. During the coding process, it was ensured that the data was read thoroughly to ensure the generation of in-depth meaning of participants' statements and not just relying on a focus of the words alone. Selective phrases and short sentences were used to inductively label emerging codes from the raw data without any theoretical restriction (Nieuwenhuis, 2014), after several readings, reflection, rereading and writing. Related codes emerging from the raw data were later classified into common categories, and each category was later assigned to emergent themes and a priori themes based on the research questions.

The five themes generated in this study were teachers' knowledge, teachers' collaboration, teachers' attitudes and beliefs, Lesson Study experience, and contextual factors and challenges. These themes were used as headings in Chapters 4 and 5 when presenting the analysed data obtained from this study. A representation of the themes with corresponding categories is presented in Table 3. 4.

Table 3-4*: Overview of the themes and their corresponding categories*

Themes	Categories/sub-themes.
Teachers' knowledge	Content knowledge Teaching strategies Knowledge of learners' difficulties Teachers' qualification
Teachers' collaboration	Teachers learning Teachers community of practice Learners' learning
Teachers' attitude and beliefs	Teaching beliefs and attitude Pedagogical skills and practice Teachers' learning Teachers' character
Lesson Study experience	Description of Lesson Study Challenges of Lesson Study Advantages of Lesson Study
Contextual factors and challenges	Resources Workload Emotions Leadership Methods involved Learning Environment

3.7 Quality assurance criteria

Considering the interpretive background of this research, it is essential to ensure the authenticity of this study. This was done to enable the researcher to confirm the truthfulness of the data and analysis obtained from the research process.

3.7.1 Trustworthiness

Trustworthiness can be described as the honest and truthful presentation of a researcher's findings, captured from the participants' perspective. The trustworthiness of a qualitative study can be established using criteria of dependability, credibility, and transferability (Lincoln & Guba, 1985; Loh, 2013; Nieuwenhuis, 2014). Trustworthiness can be enhanced through the researcher's objectivity, use of various data collection techniques, selection of participants, the help of several investigators in interpreting data, honesty, depth, richness, and scope of data (Cohen et al., 2007; Nieuwenhuis, 2014).

The credibility of this study was enhanced through participants' prolonged engagement in the study. This gave participants the opportunity to develop their understanding of the Lesson Study process and its outcome. The extended engagement of teachers in this study allowed the investigator to gather detailed information about their experiences, attitudes, opinions, and challenges through interviews, observations and document analyses. Participants were given the opportunity to consciously observe, reflect, discuss and take down notes about each other's teaching at different meetings. For accuracy purposes, information gathered from the interview was verified with the analysis of participants' document and field notes from observation. Obtained information was transcribed, participants reviewed the field notes and transcribed data at the end of the collection process to check for correct interpretation. During the data coding process, short words assigned to emergent phrases were critically discussed with two critical friends. A coding frame was later developed to avoid subjective bias in the coding process. To further guarantee the dependability of this study, I involved the help of two peer researchers as critical friends and my supervisor to check my data interpretation

3.7.1.1 Triangulation

Triangulation is described as a measure of improving the trustworthiness of research findings using various data sources, methods, theories, investigators and resources to generate understanding and ascertain the credibility of a study (Bowen, 2009; Cohen et al., 2007; Nieuwenhuis, 2014). Methodological triangulation was ensured in this study by using multiple data collection strategies (lesson observations, interviews, and teachers' reflective writings) to clarify meanings and gain more understanding of how individual participants perceived the Lesson Study process. The researcher repeatedly checked the correctness of teachers' knowledge in terms of content delivery with the intention of ensuring the validity of this study. The teacher's teaching was also cross checked with the content of the syllabus. More so, data obtained from the various sources were used to support one another with the aim of authenticating research findings. Results obtained in this study were compared with findings reviewed in the literature, to overcome issues of validity and bias from the researcher's perspective.

3.7.1.2 Crystallization

Crystallization is a data analysis strategy that enhances the trustworthiness of qualitative research.

> *Crystallization combines multiple forms of analysis and multiple genres of representation into a coherent text or series of related texts building a rich and openly partial account of a phenomenon that problematizes its own construction, highlights researchers' vulnerabilities and positionality, makes claims about socially constructed meanings and reveals the indeterminacy of knowledge claims even as it makes them* (Ellingson, 2009, p.4).

In this study, the researcher was able to examine participants' responses and actions from various perspectives. This enabled the generation of different meaningful codes that explain the effects of the Lesson Study intervention on participants' knowledge and classroom practice. More so, since the researcher was personally related with the participants during the study, she was able to tell her interpretation of what happened during the Lesson Study sessions and teachers' classroom teaching. This methodological process also helped in revealing the extent of teachers' knowledge during their classroom teaching, which the researcher regards as a problem that requires a solution. The trustworthiness of this study was enhanced using information gathered from interviews, observations and field notes to explain the effect of this Lesson Study intervention on participants' knowledge and classroom practice.

3.8 Ethical consideration

Research Ethics are norms for conduct required to differentiate between what is acceptable and not acceptable during a research process. Cohen et al. (2007) claim that living in a democratic society promotes freedom, and when limitations are placed on such freedom, the restrictions must be declared and complied to by the investigator. In this study, participants were neither restricted nor coerced to participate, but rather gave their consent to willingly take part in the study. Consideration of ethics is a very important aspect of research especially when it involves human beings as the subject of study; and this relates to potential harm to research participants, betrayal, deception, participants' informed consent and anonymity/confidentiality (Cohen et al., 2007). Any research that causes harm to its participants is considered unethical and unacceptable. Participants were assured of trust, confidentiality, and anonymity because of their participation in this study. Participants were also assured that all pictures, video and audio recordings obtained during this study would be kept in a secured location.

This study was conducted in accordance with the University of Pretoria's Ethics Regulations. A research approval and ethical clearance were obtained from the Faculty of Education Ethics Committee based on the University's regulations. Approval to carry out research in public schools within an informal settlement, as well as schools in a city was obtained from the North-West Department of Education and the Gauteng Department of Education respectively. Permission to involve teachers as research participants and observe teachers in the classroom while teaching was obtained from the school principals. More so, learners and parents/guardians were given assent letters informing them about the researcher's presence in their class before conducting the observation. To ensure anonymity, the researcher ensured that learners' faces were not captured on video.

In this study, the sampled participants were given a letter with detailed information on the purpose of the study, phases involved in the study, the time duration of the study and their role as research participants. They were later given a letter of informed consent to sign; which was retrieved back by the researcher before involving them in the study and observing their lessons. The study had a medium level of sensitivity because the participants were videotaped during their individual classroom teaching and audio-taped during the interview sessions. This was done to have an accurate and clear record of all the teaching activities and responses to interview questions. Participants were protected from all sorts of physical and psychological harm since they were treated with respect and dignity. Confidentiality and anonymity of participants and their schools were also maintained

3.9 **Limitations of the study**

This research study employed the use of an exploratory case study as it's research design approach which has its own weakness like all other research designs. According to Cohen et al. (2007, p.256) case studies

> *…are not easily open to cross-checking, hence they may be selective, biased, personal and subjective. They are prone to problems of observer bias, despite attempts made to address reflexivity. The results may not be generalizable except where other readers/researchers see their application* (Cohen et al., 2007).

Since the researcher was the principal tool of data collection and analysis, she had to rely on her instincts and capabilities all through the research. More so, the small sample size used in this study cannot give a picture of what the situation is with other physical sciences teachers across South African schools. However, the aim of this study was not to generalise, therefore an in-depth analysis of this research work was conducted using different methods for collecting data that gave insight into teachers' learning during this Lesson Study intervention.

Other factors that contributed to the limitation of this study were the distance between schools located in the province, the small number of physical sciences teachers present in a single school, teachers' expression of fear of being exposed through video recordings, uncooperative attitude of some teachers and insufficient laboratory apparatus for learners. This was a setback in narrowing the study to a specific concept under electricity and magnetism. Also, there was difficulty in finding a group of teachers willing and able to work together in a typical Lesson Study cluster. Therefore, this study was focused on Lesson Study pairs, not clusters. Learners' performance was not investigated since the purpose of this study was to understand teachers' views and behaviour during Lesson Study. However, a sample of different teachers from different districts across a specific province coming together to carry out Lesson Study would have been preferred

3.10 Conclusion

In this chapter, a comprehensive report of the research methodology was given. In the next two chapters, findings obtained from the two Lesson Study pairs separately will be presented. Chapter 4 is focused on the Grade 11 Lesson Study pair and Chapter 5 is focused on the Grade 10 Lesson Study pair.

4. CHAPTER 4: RESULTS FROM LESSON STUDY PAIR A

4.1 Introduction

In this chapter, the results obtained from a rural school as a case study that exclusively focused on the Grade 11 physical sciences teachers' Lesson Study process is presented. The data analysis presented in this chapter is based on the researcher's interpretation of participants' views and behaviours regarding the use of Lesson Study in teaching. Information about the school and detailed biographic information of the research participants are presented first. Secondly tabular presentation of the data collection process is included. Thirdly, the findings from the initial interviews based on a priori themes generated from the study, followed by the results of all Lesson Study activities, are presented. These include pair planning, individual classroom teaching, pair reflection, presentation of participants' final interviews and analysis of participants' documents.

4.2 School context

Constant High School is a public technical and commercial school located in one of the old communities outside the town centre. The Grade 12 pass rate for physical sciences learners in this school was below 40% in 2015. Participants in this school are pressurised by the district office not to fail the learners in lower grades and promote them even when they score below the pass mark. The school buildings and its environment are neat. The physical science laboratory is well equipped with furniture required for learning but the laboratory lacks some basic practical apparatus needed for teaching topics like electromagnetism. The laboratory also has a multimedia system (projector) which can be used to facilitate effective teaching and learning of physical sciences but it is not used. Instead, the physical science laboratory in this school is used as an office for physical sciences and mathematics teachers in the school. The laboratory has a photocopying machine which the school uses for photocopying all important documents needed by the staff and learners. The learners have science classes in their ordinary classrooms instead of the laboratory. The medium of instruction is English but teachers and learners often use their home language. According to the participants in this group, most of their learners don't speak

English outside the classroom so teachers use both English and Setswana to explain difficult concepts when teaching physical sciences. Participants are teaching physical sciences to learners who don't have textbooks. Participants reproduce text materials by distributing photocopies of textbook and workbook pages on the lessons to be taught to learners.

4.3 Biographic Information

The Lesson Study pair at Constant High School comprised of two physical sciences teachers Lenox and Mbali. Pseudonyms have been used in this study to protect the participants' confidentiality and identities. A detailed representation of the participants' information has been provided in Table 4.1. These two teachers had different years of teaching experience and they teach physical sciences to learners from Grade 10 to 12. Based on the different teacher's experience in science teaching, it could be expected that teachers understanding of specific content knowledge and pedagogical skills in teaching electricity and magnetism would differ from one another. The two teachers from this school were selected based on their availability and readiness to participate in the study.

Table 4-1: Biographical information of participants in Lesson Study pair A

Pseudonym	**Lenox**	**Mbali**
Gender	Male	Female
Qualifications	Secondary teacher diploma in education; ACE (Math and Science)	ACE (Science) and Diploma (Mathematics Literacy)
Total years of teaching experience	18	12
Years of teaching physical sciences	18	3
Grades teaching	11PS, 12PS, 10M	11PS, 12PS, 10 ML
School Type	Rural	Rural
Laboratory resources	Poorly resourced	Poorly resourced

ACE - ADVANCED CERTIFICATE IN EDUCATION; PS – PHYSICAL SCIENCES, M - MATHEMATICS, ML – MATH LITERACY

From Table 4.1, it is clearly evident that both teachers have the basic qualifications required to teach physical sciences within the South African context and they have a teaching experience of more than two years as required by my selection criteria.

4.3.1 Lenox

Lenox is a male teacher with a three-year secondary diploma in education and a two year Advanced Certificate in Education (ACE) in mathematics and science. He taught physical sciences for eighteen years in a public school with a laboratory but no equipment. According to Lenox, he never liked the teaching profession because his desire was to be an engineer. However, he became a teacher due to circumstances explained below:

> *I never intended to be a teacher. I became a teacher by default because my parents passed away and the person taking care of me said its better I become a teacher since ACE was free as at that time and I already had my diploma in education. So, I opted to do ACE because it was free and that was the criteria for becoming a teacher back then.* (Lenox)

Lenox indicated that he would like to further his studies when applying for a leadership position. He said:

> *I am still going to do a degree but that is when I am about to get one of this leadership role either as HOD or something. If I am doing a degree it will be in another course and not in math or science because math and science are difficult I tell you.* (Lenox)

Lenox believes that science is a difficult subject. It is possible that his perception about the difficult nature of science could negatively influence his classroom practices. He believes that having an additional degree in the field of science is a waste of time since all science teachers receive the same salary regardless of their qualification.

4.3.2 Mbali

Mbali is a female teacher with a three years' diploma in mathematics literacy and two years ACE in science. She has been teaching mathematics literacy for seven years and has now been teaching physical sciences for three years in a public school with a laboratory but no equipment. She believes that teaching physical sciences is more difficult and requires a lot of preparation.

> *To be sincere with you, I still enjoy teaching math literacy than science. When teaching math literacy, you sometimes don't need to prepare before going to*

*class. Once you flip through the resource material you can easily understand what to teach but that is not the same for science. I have to prepare over and over before I can go to class to teach this physical science.(*Mbali)

Mbali's comment on "preparing over and over" shows that she battles with science teaching. This implies that Mbali's understanding of specific physics content may have an effect on her classroom teaching.

4.4 Data collection and analysis

Details of the data collection process have already been discussed in Chapter 3 of this dissertation. The timeline of the data collection process, for pair A, is presented in Table 4.2.

Table 4-2: Timeline for data collection process for Lesson Study Pair A

Lesson topic	Participants	Date	Data gathering technique
None	Lenox Mbali	2/9/2016 5/9/2016	Initial interview
Induced current and induced magnetic field	Lenox, Mbali	5/9/2016	First group planning of lesson 1
	Lenox Mbali	6/9/2016 8/9/2016	Classroom observation for lesson 1
	Lenox, Mbali	9/9/2016	Second group planning of lesson 2; First reflection on lesson 1
Magnetic field strength, magnetic flux, and Faraday's law	Lenox Mbali	12/9/2016 14/9/2016	Classroom observation for lesson 2
	Lenox, Mbali	15/9/2016	Third group planning of lesson 3; Second reflections on lesson 2
Electrical Circuits: series, parallel and combined circuits	Lenox Mbali	19/9/2016 21/09/2016	Classroom observation for lesson 3
	Lenox, Mbali	22/9/2016	Final reflection on lesson 3
None	Lenox Mbali	22/9/2016 23/9/2016	Final interview

4.5 Presentation and analysis of the initial Interviews

The purpose of the initial interview has been explained in Section 3.7.1. All interviews were audio recorded and transcribed based on each participant's responses. Example of participants' interview response that are significant to the research questions are presented as evidence of participants' different perceptions (Anderson, 2010). For some questions, participants responses were not relevant, in such situations, response were coded and categorised based on the meaning conveyed. There were also scenarios where the participants gave confusing responses which the researcher did not probe further in order not to upset the participants by pressurising them. The recorded initial interview was analysed according to emergent codes and categories. The results are then presented separately for the two participants, according to pre-determined and emergent themes. A summary of the emergent codes, categories and themes created during the initial interview with Lesson Study Pair A is presented in Table 4.3.

Table 4-3: List of codes, sub-themes, and themes created during initial interview with Lesson Study Pair A

Codes	Categories/sub-themes	Themes
Teacher's poor understanding of electromagnetism Teacher's own content knowledge	Teachers' content knowledge	Teachers' knowledge
Teacher's confidence teaching specific content Teacher's interest in particular lesson Giving specific instruction Expectation from learners Practical activities Use of several worked examples	Teaching strategies	
Teacher's understanding of learners learning difficulties in the topic Teacher's reaction to common learners' difficulties No learners' assessment at matric level Learners understanding of topic Learners previous knowledge background Learners negative attitude Learners performance Learners belief Fear of mathematics Learners inability to visualize the topic	Teachers' knowledge of learners' difficulties	
Teacher's expectation from learners On the spot test Learners' engagement in class discussions.	General pedagogical knowledge	
Exchange of ideas through phones; Little time available for collaboration Too many responsibilities Teacher rarely involved in practical group discussion with colleagues	Teachers' collaboration prior to Lesson Study.	Teachers' collaboration
Teacher's attitude towards further studies; Teacher's attitude towards electromagnetism;	Teachers' attitude	

Teacher’s belief on learners learning difficulties; No learners’ assessment at matric level. Teacher’s perception that math and science are difficult; Teacher’s perception about electricity Teacher’s perception of learners’ problem	Teachers’ beliefs	Teachers’ attitudes and beliefs.
Learners don’t take time to practise Learners are dependent on teachers Learners don’t have textbook Teacher has to repeat instruction Learners’ lack understanding of previous knowledge Teacher’s attitude	Teachers’ perceived challenges on practice	Contextual factors and challenges

4.5.1 Lenox’s initial interview

The initial interview with Lenox was conducted on a Friday afternoon in the physical sciences laboratory which is used as an office by other physical sciences and mathematics teachers in the school. The laboratory was conducive to the interview because other teachers were not present in the laboratory. The interview was conducted for a duration of sixty minutes.

4.5.1.1 Teachers’ collaboration prior to Lesson Study

During the first meeting with Lenox, he initially showed a negative attitude towards participating in this study. This was observed during a casual conversation when he said that collaborating with other teachers is always “a big problem” and it is sometimes demoralising and a waste of time. During the interview, the discussion continued as follows:

> **Researcher:** *Do you discuss difficult concepts in physical sciences with your colleagues in/outside the school?*
>
> **Interviewee:** *Yes, I am very open to my HOD because she also teaches physical sciences and I also have colleagues in other schools who I call on the phone to ask them questions on whatever challenges or difficulties I am having in my class or with a particular lesson. But we don’t have enough time to sit down together and discuss due to extra activities in the school which requires our attention.*

Within the school, Lenox sometimes asks his head of department to clarify some challenging questions and experiences. However, the method of collaborating with other teachers from outside his school is through mobile communications. His response indicates that this kind of phone collaboration does not give him the opportunity to critically discuss his classroom challenges. His response also indicated that his job responsibilities as a teacher do not give him time to collaborate outside the school. He uses the opportunity of coordinating and marking the Grade 12 matric examination as a way to collaborate with other teachers. This implies that Lenox rarely involves himself in a group discussion with his colleagues.

.

4.5.1.2 Teachers' knowledge

Teachers' knowledge as used in this study comprises of the teaching knowledge required by teachers (content knowledge, knowledge of teaching strategies, knowledge of learners' difficulties and general pedagogical knowledge).

Lenox's understanding of learners' difficulties in electricity and magnetism is explained below:

> ***Researcher:*** *Okay, so from your own classroom experience, what are the difficulties or misconceptions you think learners face in electricity and magnetism?*
>
> ***Interviewee:*** *See Ga ke tlhaloganye. I really don't understand these learners but I think this problem starts with the introduction of electricity and magnetism as at Grade 10. In electromagnetism, learners find it difficult to identify the direction of magnets in a solenoid. Also, this in-page and out of page description in the curriculum or the textbooks are not explanatory enough to some of them. Another thing I may say is that these learners don't really understand the meaning of a change of magnetic flux and because of this when they are asked some questions they don't know that changing the area of a coil will automatically change the flux. In electrical circuits, these learners have the same fear for the electric circuit as they have for mathematics. So, they put this immediate barrier that they cannot do it once they hear electricity. I will say the general fear is that electricity is difficult to comprehend. Also, they cannot differentiate between parallel and series arrangement and the situation becomes worst when you combine parallel and series arrangement in a circuit*

diagram. They don't understand the difference between electromotive force and potential difference, so calculating it becomes a nightmare to them. *Eeeem...my sister, so you see that if they cannot visualise the topic or maybe I call it the concept, then they see it as abstract and all they do is just memorise for the sake of passing the exam.*

Initially, Lenox was unable to immediately answer the question on learners' difficulties in electricity and magnetism. But further probes for clarification gave him the opportunity to demonstrate his knowledge of learners' difficulties in electricity and magnetism. Lenox believes that learners' emotional feelings towards a concept is a significant factor that contributes to learners' difficulties in electricity and magnetism. He indicated that learners' difficulties start from their background knowledge. His awareness of learners' difficulties in this topic also signifies a representation of his own content knowledge.

> ***Researcher:*** *How do you address the difficulties that learners have in electricity and magnetism?*
>
> ***Interviewee:*** *In the electrical circuit, I do tell them to first take up the parallel arrangement, solve it the put it back in the circuit diagram to calculate the series circuit. For electromagnetism, I try as much as possible to do practical activities whenever apparatus is available and I encourage them to carry it out individually. Above all, I will say I use quite a numerous example to address their difficulties.*

Lenox's response shows that he does not use the traditional teaching method alone in addressing his learners' difficulties. It seems that he is aware of several teaching methods like practical activities, problem-based learning and the use of several worked examples and he indicated that he uses them in addressing his learners' difficulties. However, his comment on "doing practical whenever apparatus is available" remains unclear since he did not explain to what extent practical activities is done, given the fact that the lab is not used and lacks basic equipment. He also demonstrated his knowledge of active-learning strategies which include the teaching of difficult concepts from simple to complex. For example, when he indicated that he tells learners to first take up the parallel arrangement solve it and put it back in the circuit diagram to calculate the series circuit when solving problems in the electrical circuit. His response shows that he understands how to transform and translate specific lesson content into teaching. Lenox mentioned that he uses learners' previous knowledge as his own practice of introducing new or similar lessons to learners. During the interview, Lenox did not clarify if he finds the content on electromagnetism difficult but his response to further questions asked shows that he lacks content knowledge on the topic.

> ***Researcher:*** *As a teacher is there any concept of electricity and magnetism that appears confusing or difficult to you?*
>
> ***Interviewee:*** *Hmm……not really in Grade 11, but. I am not too confident teaching a topic like electromagnetism this because even as a teacher I don't like the topic too. The topic is just too......... (ga ke itse sepe) I don't know how to explain. You see em, for Grade 12 am still not confident with teaching the concept of generators and motors. I just have to read, read and read to understand some things at the Grade 12 level. This will be my second year of teaching Grade 12.*

4.5.1.3 Teachers' attitudes and beliefs

The topic electromagnetism is part of the syllabus which must be taught in Grade 11 but not examined in the final Grade 12 examination. For this reason, Lenox does not regard learners' difficulties in electromagnetism as a serious problem. This was noticed during the following conversation.

> ***Researcher:*** *In your experience as a physical sciences teacher, what can you say about learners' difficulties or misconceptions in electricity and magnetism?*
>
> ***Interviewee:*** *To those of us marking, we believe that learners have a problem with energy theorem and electricity. Although electricity or electric circuits as they call it is very simple but learners still find the topic difficult. Pertaining to electromagnetism. When we moderate for marking, we hardly consider electromagnetism as a difficult topic because learners are not assessed on that topic at the matric level.*

Lenox's reaction indicates that he has a negative attitude towards electromagnetism. He regards electromagnetism as not difficult since learners are not assessed on the topic in their matric examination. His understanding of difficult topics is based on identified learners' academic weaknesses which may influence their results in marking in the final Grade 12 exams. Lenox's response regarding learners' difficulties was viewed from his professional experience as an examiner and not as a classroom teacher. Lenox was not ready to admit that he is finding some topics under electricity and magnetism difficult as a teacher. But his attitude while responding to the question showed that he is not enthusiastic about teaching a concept like electromagnetism because he has no interest in the topic.

4.5.1.4 Contextual factors and challenges

During the interview, Lenox shared his ideas and experiences on factors affecting his classroom practice. This is portrayed in the following conversation.

> ***Researcher:*** *How do learners' difficulties and misconceptions on this topic affect your classroom practice?*
>
> ***Interviewee:*** *You know these difficulties and misconceptions as you put it was from their Grade 8/9 probably because the teachers who taught them did not do their job well. But for me, I have learned to always try introducing the basic to them again before moving on with what they expected to know at Grade 10 to 12. Although this step takes me back a lot and consumes most of the time. And to be sincere with you, sometimes I just carry on with my (thuto) teaching if I see that I don't know how best to explain to them again.*

Lenox believes that addressing learners' difficulties is always time-consuming since the time allocated for teaching the subject is not sufficient. His response indicates that he has a habit of moving on with lessons whenever he finds it difficult to explain the concept in a way that learners understand. As a result, it is concluded that this behaviour may affect learners understanding of lessons which Lenox find difficult to explain. Based on his response to this question, it seems that Lenox's method of addressing learners' difficulties is inadequate. During his explanation on how to identify that a learner has successfully overcome the difficult concept he is teaching, he mentioned that learners are expected to ask questions or come to him when they don't understand a concept. He believes that it is the learners' responsibilty to ask questions if they have difficulties. However, the researcher believes that not all learners have the courage to ask the teacher questions on topics they are struggling with. More so,it is the teacher's responsibility to assess learners understanding.

Lenox also attributed his teaching challenges to the absence of teacher development programmess and a subject adviser at the district level. He stated that he used to attend science workshops during the dinaledi periods, however, he has not attended any practical professional development training/workshops in five years. Instead, he personally involves himself in a different kind of training through marking matric examinations**.** He believes that the absence of a professional expert at the district level has a negative impact on all physical science teachers within the district. This was observed when he said:

> *"Many educators especially the new ones are definitely facing problems in their classrooms and they don't know how to resolve those problems. So, educators are left to handle the challenges on their own".*

Lenox indicated that veteran teachers like him are also affected but he knows how to solve his problems since he has colleagues in other schools which he can easily contact. He went further to explain that he discusses some of his classroom challenges with other examiners in moderation, but indicated that having a subject adviser would have been the best. During the interview, Lenox did not directly answer some questions but his responses indicated that he is also facing some challenges in topics under electricity and magnetism. The researcher also considered the use of the laboratory as an office and the lack of basic equipment as mentioned in Section 4.2 as a contextual factor. Taking a critical look at his previous response to questions asked, Lenox's perception, attitude and beliefs on learners' difficulties in electricity and magnetism have a significant effect on his classroom practice. There is a clear indication that Lenox needs to be involved in practical professional training that could help him improve his professional knowledge, perception, attitudes, and beliefs.

4.5.2 Mbali's initial interview

Teacher collaboration within the context of this study refers to the mutual agreement between physical sciences teachers coming together to identify learners' academic challenges or discuss teacher's classroom challenges and offer solutions to those challenges. Though Mbali did not talk about the difficult and confusing concepts she might be facing as a teacher when teaching electricity and magnetism she was then asked on how she discussed difficult concepts she encounters with her colleagues in the same school or another school.

> ***Researcher:*** *Do you discuss this difficult concept with your colleagues in/outside the school?*
>
> ***Interviewee:*** *When I was teaching math literacy, yes, I discuss with my colleagues in school and our discussion is basically on better ways or alternative approach to solving a problem but they are not really detailed. Although it's been quite helpful talking to someone like my colleagues on some difficulties I face while teaching. Since I started teaching physical sciences I would say not really because I have not had the opportunity to meet with other physical sciences from other schools and the person teaching the technical section of the school is too busy with the association and other things.*

Mbali indicated earlier that she has been teaching physical sciences for three years. Her response reveals that she has not had an opportunity to collaborate with other physical sciences teachers inside or outside her school. She believes that her colleague at school is too busy for collaboration. This implies that Mbali plans and teaches her lessons in isolation.

4.5.2.1 Teachers' knowledge

Mbali indicated that she was formerly teaching mathematics but now teaching physical sciences due to the present need of teachers in the field. She believes that her ACE certificate has provided her with the required knowledge needed to become a physical sciences teacher. Mbali demonstrated her knowledge of learners' difficulties and characteristics in the conversation below.

> ***Researcher:*** *What are these difficulties and misconceptions?*
>
> ***Interviewee:*** *They struggle with Faraday's laws of induction, the direction of the induced current, magnetic field, solenoid and how to determine the direction of the field at angles. Something I think........ I noticed as well is that some learners take the direction of the field as the flow of current. Then you see this concept of a magnetic field associated current carrying wires. Yooooooo it is*

confusing to learners and even to some educators. In electricity, learners don't know how to correctly substitute equations when solving problems and funny enough am still shocked that these learners can neither state nor apply Ohms' law correctly.

Mbali's response indicated that she understands learners' difficulties in electricity and magnetism. Her ability to describe the learning difficulties also gave her the opportunity to demonstrate her own content knowledge. The teacher believes that learners encounter problems in electrical circuits because they cannot apply mathematical concepts properly. Mbali indicated that some concepts are also confusing to educators. This gave me an opportunity to ask a follow-up question. Mbali explained the various strategies she has used in addressing learners' difficulties and misconceptions in the conversation below:

> ***Researcher:*** *How do you address the difficulties and misconceptions that learners have in these areas?*
>
> ***Interviewee:*** *I try as much as possible to explain to the best of my knowledge and I do a lot of class activities with them. Sometimes I encourage them to solve questions individually but unfortunately, there is not enough time to mark all their books. So, I ensure that they exchange their books to mark as I do the correction on the board.*

Mbali demonstrated her pedagogical knowledge by representing the lesson content in her own understanding using appropriate class examples and applications. Though Mbali attempts to address learners' difficulties by solving the problems on the board while learners exchange their books, it cannot be said that her method of addressing learners' difficulties is effective. When clarifying her knowledge of learners' learning she mentioned learners' classroom interaction and facial expression as a clear way of determining learners' learning. She said, "when learners understand a lesson you see it in their reaction, the way they answer questions and I also look at the way they interact with one another when I give them pair activities". More so, she sometimes uses a collaborative learning approach by observing the way learners interact with one another whenever she gives them pair activities as a way of teaching her lessons.

4.5.2.2 Teacher's attitudes and beliefs

Mbali believes that learners' difficulties in physical science is a general problem which cuts across all grades. She mentioned that learners' difficulties are common because of learners' negative attitude and lack of interest in physical science as a subject. She indicated that learners have problems with electricity and magnetism due to the nature of the topic. She also attributed the widespread occurrence of learners' difficulties in physical sciences to the promotion criteria used for learners at the FET level when she explained that learners may be promoted despite failing in physical sciences. The researcher probed for clarification on the prevalent nature of learners' difficulties in physical sciences.

> ***Researcher:*** *How common are these difficulties and misconceptions among learners?*
>
> ***Interviewee:*** *Hmm ..these difficulties are very common and it cuts across Grade 10 and 11, 12 because when learners don't pass mathematics and physical sciences in one grade they will still be promoted to the next grade once they are able to pass 6 or 8 subjects. So, whatever problem they are struggling with for instance in Grade 10, they move with it to Grade 11 and 12. So you find out that these learners don't have the basic understanding of physical sciences topics at Grade 10 then how do you expect them to build on it at Grade 11 and 12. It becomes a big problem for educators teaching Grade 11 and 12 learners. We cannot teach them the basics at this grade so we just try our best to explain in our own little way but remember the foundation is weak.*

When elaborating on her interview response to the prevalent learning difficulties among learners, she constantly referred to learners' perception and attitude towards the subject. She believes that learners are not ready to understand specific topics since "they cannot visualise the concept in their environment". It seems that Mbali was trying to say that learners' inability to conceptualise a topic caused them to view such topics or concepts as being abstract in nature and difficult to comprehend.

While elaborating on her beliefs about learners' difficulties and teachers perceptions of difficult concepts, she said: "*I won't say I don't face some difficulties with this electromagnetism concept because I will say it's newly introduced in some way but* *sorry I won't say much about this one".* She also indicated that teaching mathematics literacy was easier than teaching physical sciences. This was confirmed when she said she still "…enjoys teaching mathematics literacy than science" and also emphasised later in the interview when she stated that teaching physical sciences requires a lot of reading and preparation; unlike mathematics literacy where a teacher can easily flip through the resource material and comprehend its content. Even though Mbali was not ready to give further clarifications on the aspects where she is challenged, her response implies that she still finds the content on electricity and magnetism difficult.

4.5.2.3 Contextual factors and challenges

Questions were asked on Mbali's classroom challenges as portrayed in the below conversation.

> ***Researcher:*** *How do learners' difficulties and misconceptions on this topic affect your classroom practice?*
>
> ***Interviewee:*** *Difficulties or misconceptions as you put it can only be cleared up when learners take the time to practise on their own. Learners' difficulties affect my teaching because they don't have textbooks or workbooks to enable them to do homework or practise on their own. They depend on the educator for everything from questions to solutions. So, I tend to repeat some explanations over and over. I try to make sure that at least 30% to 40% of the class can understand what am saying before I can move to the next lesson. So, I sometimes don't achieve what I plan to do, I just follow the situation in my class for the day. Despite the extra activities I give them, they still struggle to understand the concept of electromagnetism and the combination of series and parallel arrangement in electricity.*

Mbali's response revealed that contextual factors such as lack of learners' resource materials contributed to the widespread difficulties in electricity and magnetism. The teacher believes that those contextual factors directly slow down the rate at which she teaches the learners. Due to these contextual factors, it seems that many learners in Mbali's class do not follow the teaching since she stated that she tries to make sure that at least 30% to 40% of her class is able to understand what she is teaching before moving on to the next lesson. It seems that this kind of teaching practice affects learners' learning and that is why the learners still struggle with basic concepts as indicated in the teacher's response. Mbali also attributed the absence of a subject adviser at the district level and lack of professional development opportunities for physical sciences teachers as factors affecting her classroom practice. She said:

> *I am facing problems in my class and sometimes I don't know how to resolve those problems. So, I will say I am left on my own to handle situations that are beyond me which indirectly affects the learners. For example, on this topic of electromagnetism, we don't have any apparatus in my school and there is no subject adviser to help me out on other ways of teaching the practical to learners so I just verbally explain to them and continue with other aspects of the lesson. It's hard for somebody like me but what can I do.*

She indicated that physical sciences teachers in the district are unable to collaborate due to the absence of a subject adviser which have deprived teachers of participating in professional development in the last five years. She also identified the absence of laboratory equipment as one of the factors affecting her classroom practice. Mbali does not conduct practical activities with learners when teaching concepts in electromagnetism due to lack of apparatus. Of course, this does not mean that Mbali does not have the practical skills required in teaching the topic. The absence of a subject adviser at the district level was also mentioned as a contextual factor that negatively affected some teachers' classroom practice, since they are left to personally deal with whatever challenges they encounter.

In summary, the initial interview of both teachers reveals that these teachers need to be exposed to practical professional training that could help them improve their professional knowledge, as well as change their attitudes and beliefs about learners' difficulties and the teaching of science.

4.6 First planning session by Lesson Study pair A

The first planning meeting took place on a Monday afternoon. Participants were given a detailed explanation on what the study entailed as discussed in Section 3.6 (see also Figure 3.2 and 3.3). The pair of teachers jointly identified learners' difficulties in electricity and magnetism based on their classroom experiences. During their discussion Mbali said, "*the difficulties are basically mathematical problem and this issue of determining the direction of magnetic field in a current carrying wire"*. Lenox also indicated that learners have problems with the application of Faraday's law and the combination of circuits. They outlined key points mentioned during their discussion, as they aligned the lesson planning on learners' challenges with the curriculum. Learners' challenges as identified during the teachers' brainstorming session was grouped under the magnetic field associated wih a current, Faraday's law of electromagnetic induction, and electrical circuits.

Based on the outline of topics in the curriculum, the first research lesson planning was on the magnetic field associated with a current. They agreed to equally distribute Lesson Study tasks among themselves. They were given copies of the Lesson Study plan template provided in Appendix 8 as part of the materials used in planning the research lesson. Lenox was responsible for writing the lesson plan while Mbali was responsible for summarising the content of what the lesson should cover. During the planning, they used curriculum documents, different textbooks and workbooks as shown in Figure 4.1.

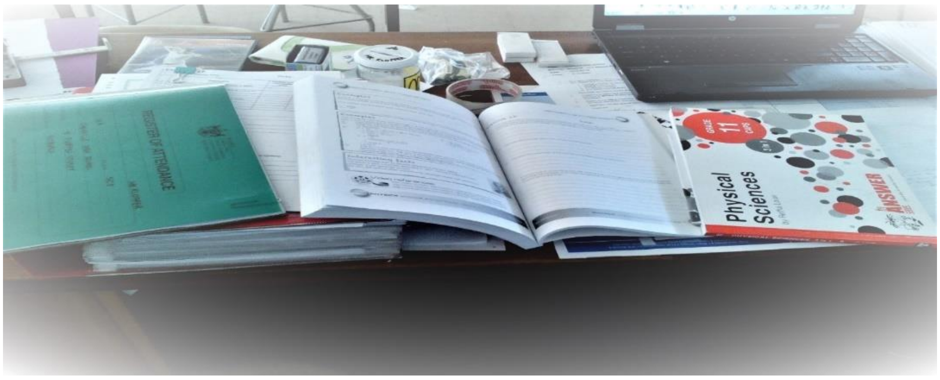
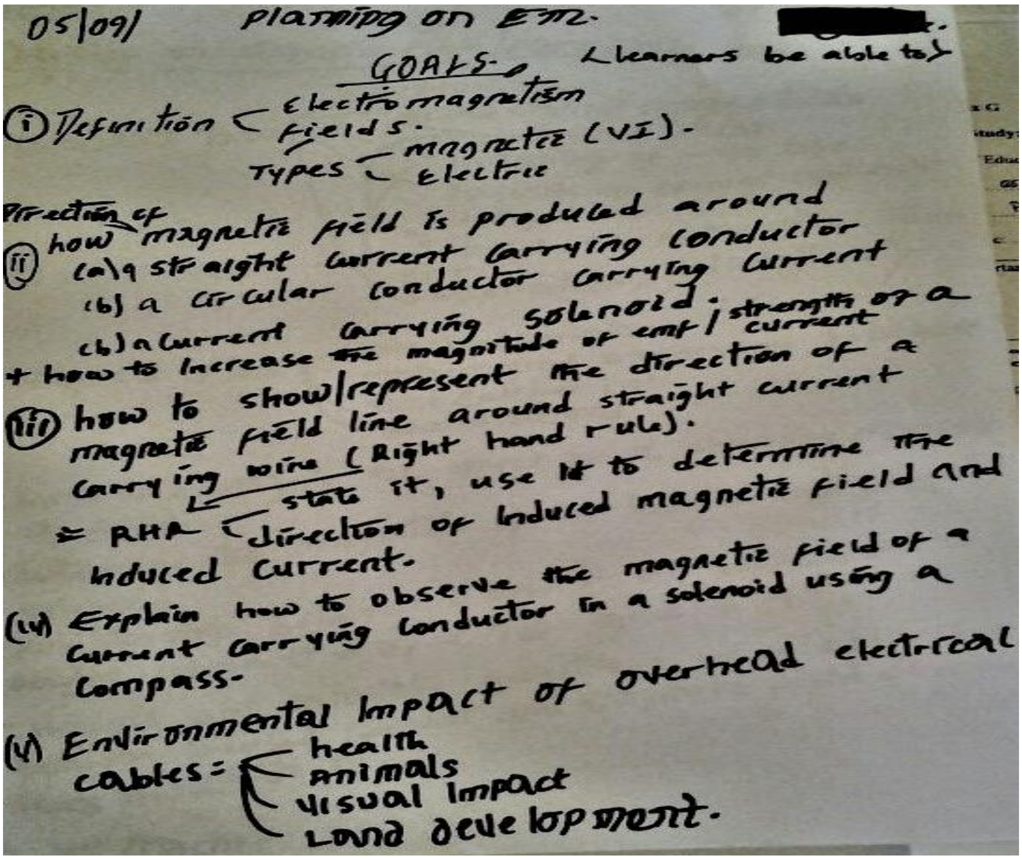


Figure 4-1: Teaching materials utilised by Lesson Study pair A during the planning meeting

During the meeting, Lenox and Mbali had a detailed discussion on how to teach the lesson on fields of current carrying conductors. Their discussions were focused on the criteria outlined in the Lesson Study plan template in Appendix 8. These include the importance of the topic to learners, teaching resources and methodology, goals/objectives of the lesson, learners' previous knowledge, learners' future knowledge, use of key vocabulary words, lesson introduction, class activities, conclusion, feedback, homework, and reflection. During the first planning session, it was observed that teachers could not clearly relate the importance of the first research lesson to learners' learning. However, they outlined the goals of the lesson as shown in Figure 4.2 and as indicated in the prepared Lesson Study plan in Appendix 15. Analysis of the lesson goals summarised by Mbali revealed that there are gaps in their planning. Also, what Lenox wrote in the lesson plan did not align with the discussions held during the planning meeting. The lesson introduction and teacher's expectations indicated in the lesson plan (see Appendix 15) revealed that Lenox's content and pedagogical knowledge were poor.


05/09/ planning on EM. [redacted].

GOALS (learners be able to)

(i) Definition < Electromagnetism
Fields.
Types < magnetic (VI).
Electric

Direction of how magnetic field is produced around
(ii) (a) a straight current carrying conductor
(b) a circular conductor carrying current
(c) a current carrying solenoid; strength of a current
+ how to increase the magnitude of emf / current

(iii) how to show/represent the direction of a magnetic field line around straight current carrying wire (Right hand rule).
state it, use it to determine the
= RHR < direction of induced magnetic field and induced current.

(iv) Explain how to observe the magnetic field of a current carrying conductor in a solenoid using a compass.

(v) Environmental impact of overhead electrical cables: < health
animals
visual impact
land development.

Figure 4-2: Summary of content on the first research lesson as planned by Pair A during their First Lesson Study planning meeting.

During their conversation, Lenox indicated that the school did not have apparatus for a practical demonstration of the first research lesson as outlined in the curriculum. In his own words.

> **Lenox:** *"You see that we don't have some required laboratory apparatus in this school, so it's possible that we will be using only the explanation method for the first lesson you want to observe."*

However, further conversations between these teachers indicated that the teachers sometimes go to a nearby school to collect apparatus for practical sessions and return it after use. This was confirmed when Mbali said:

> *"Since the experiment is recommended in the curriculum, we will arrange with our neighbouring school for practical equipment on the lesson to enable learners to have a first-hand experience of the concept being taught."*

Mbali explained how she will get the equipment from the neighbouring school. This was observed when she said, "It depends on whether the school has the required apparatus and if the teacher in that school is through with the lesson". It seems learners may likely not understand the direction of fields due to lack of apparatus. So, the teachers agreed to explain the direction of a magnetic field by describing a simple experiment on how a compass deflects when placed near a straight conductor through which current is flowing. Teachers also brainstormed on how learners can identify the direction of current and field, drawing diagrams of conductors and using arrows as indications of the directions. The Lesson Study pair considered various possible ways of explaining the lesson. Lenox suggested that learners can identify the direction of current and magnetic field using their right-hand from the concept of the right-hand rule. He demonstrated this action by pointing his right thumb to himself and indicated it as the 'dot for out of the page' while he pointed his right thumb in the opposite direction and indicated it as a 'cross for into the page'. This is a simple explanation of how learners can indicate the direction of flow of current. Mbali agreed to use the rule in her classroom as well. The teachers practised a few practical orientated activities outlined in the learners' workbook and this gave them the opportunity to anticipate learners' response to the practical orientated activities. During the lesson planning and preparation, the researcher assisted teachers in answering questions that appeared confusing to them.

4.7 **Classroom observation for the first research lesson**

After the first planning session, the Lesson Study pair presented their first lesson on magnetic fields of current carrying conductors. The lesson presentation was done during normal class activities and narrated in the next section.

4.7.1 Lenox's first lesson presentation

Lenox presented his lesson to Grade 11 learners from the technical section (class T4) of the school. The bell for Lenox's class rang at about 10:15 a.m. in the morning. Learners were still busy with their drawing activities from the previous class when Lenox walked into the class. He waited for the learners to put away all materials that will not be used in his class. The teacher allocated a chair to me behind the classroom where I could see both teacher and learners clearly. Lenox greeted the learners and introduced the new lesson (electromagnetism) to them. He immediately handed over photocopies of textbook pages on the topic to be taught to all learners in the class because most of the learners don't have textbooks. The photocopied document contained several concepts to be addressed under electromagnetism. Lenox assessed the learners' previous knowledge by giving the learners a short-written class activity on the explanation of magnets and properties of a magnet. After five minutes the teacher asked learners (A1 and B1) to give the answers to the activity.

> ***Learner A1:*** *"A magnet is a material that has the properties of attracting other materials to itself; properties of magnet…….eish. "*

Learner B1 did not answer the question. Due to the time allocation for the period, the teacher decided to write the correct answer on the board as other learners in the class were responding. The teacher clearly stated the aim of the lesson from the beginning and he related the topic to learners' previous knowledge on electrostatic force and magnets. When he said:

> ***Lenox:*** *"In this chapter, you will learn what happens when you bring a magnet near a current carrying conductor just like you did when you were bringing the North and South Pole of a magnet together; and you were able to describe the magnetic field between this pole and you know we did the same earlier in electrostatics."*

Lenox continued his teaching by verbally explaining a simple experiment on how to determine the direction of the magnetic field around a straight wire carrying conductor using a compass as discussed during the planning session. Learners were unable to perform this experiment as prescribed in the curriculum due to the absence of apparatus in the school. Lenox explained how learners can use their right-hand to identify the direction of a current and magnetic field around a solenoid stating the right-hand rule. He pointed out to learners that the magnetic field pattern outside a solenoid is curved like that of a bar magnet but it is straight in the middle of the solenoid. He used a few activities in the photocopied workbook page as examples to aid learners' understanding on how to determine the direction of the magnetic field and he encouraged learners to practise more activities in the workbook. During the explanation, some of the learners had facial expressions which indicated that they did not understand how to determine the concept of in page and out of page as explained by the teacher. Lenox re-explained the concept using his right thumb. He asked all learners in the class to also do the same as they fold their fingers pointing their thumbs to themselves. Lenox used the concept of the thumb as a point and a cross method to enhance learners' understanding on how to determine the direction of a magnetic field around a conductor using the right-hand rule . Learners indicated that they now understood the concept better by shouting "*oooooooooh*". Lenox assessed learners' understanding of the lesson by asking them to explain how they can determine the direction of the magnetic field around a conductor . While learners were busy with this activity, Lenox went around the class to mark learners' activity individually as portrayed in Figure 4.3.

Figure 4-3: Lenox moving round to mark learners' class activity

Lenox found out that not all learners attempted the activity. It seems that he believed that if the learners had understood what he taught them they would have willingly attempted the class-activity. This implies that learners' unwillingness to attempt the class activity was an indication that they did not understand the topic as explained. Lenox encouraged learners to always attempt a class-activity to enable the teacher to know if they understood the topic or not. Lenox called out three of the learners to the front of the class and asked them to explain their answers to other members of the class. Unfortunately, the time allocated for the class activity was not sufficient as the three learners were unable to present their answers neither was Lenox able to give a clarification on the correct answers to the questions before the bell rang for the next period. He promised to provide them with detailed correction on the class-activity in the next class.

4.7.1.1 Analysis according to observation schedule

The data collected when observing teachers' lesson was analyzed based on basic components identified in the observation checklist. These components include assessment of learners learning, instructional delivery, classroom interaction and teacher's knowledge.

Assessing learners' learning

This includes various methods used by the teacher to verify learners understanding as well as clarifying teacher's expectations from learners. Lenox related the lesson to learners' previous knowledge by asking them to explain what a magnet was and to state the properties of a magnet. Learners' response to questions on previous knowledge was also used as a foundation for explaining the new lesson. Lenox's explanation on the direction of current perpendicular to a two-dimensional surface gave him the opportunity to involve the learners in class discussion. The teacher also assessed learners learning by moving around the class to check and mark learners' class-activity. At the end of the first lesson, Lenox did not summarise the major points of the lesson before leaving the class.

Instructional delivery

In the first lesson, Lenox gave a general review of the lesson when he told the learners that they will be learning about what happens whenever they bring electric current near a magnetic material. He managed the disruptive behaviours of the learners by keeping them attentive. Lenox presented the learning activities to support and reinforce the content of the planned goals and objectives as discussed in the planning meeting. He also explained minor learners' difficulties with clarity when he demonstrated the concept of in page and out of page, and learners expressed their understanding by shouting "*oooooooooh*". He used a direct instruction approach by re-explaining a specific concept based on learners' request. Lenox's clarification of learners understanding signifies that he was committed and enthusiastic about the learners learning. He used various relevant activities from the workbook to enhance learners understanding of the supposed practical concept involved in the lesson. This shows that Lenox had a fair and equal concern for how his learners learned. However, the teacher did not emphasise important points that learners must know. He did not integrate examples from the real-world into his teaching.

Classroom interaction

This involves the teacher's approach to enhancing the teaching and learning process through the development of learners listening and speaking skills. During Lenox's class observation, he used the appropriate keywords in explaining basic concepts of electromagnetic induction. He did not use any form of group activity among learners' due to the absence of laboratory apparatus. He demonstrated the concept of in page and out of page using the thumb and promoted independent work among learners. This was achieved when he asked the learners to all demonstrate the concept by folding their right fingers across their thumb pointing to themselves as "in" and pointing to the opposite direction as "out". However, Lenox did not ask questions to monitor learners learning. The teacher demonstrated flexibility in his classroom by actively encouraging learners to ask questions. Lenox had a good rapport with the learners and demonstrated respect for diversity by calling both male and female learners to participate in class activities.

Teacher’s knowledge

Lenox presented the material at an appropriate level for the learners, this presentation also corresponded with the planned objectives of the lesson as discussed in the planning meeting. However, the lesson plan presented by Lenox after the planning meeting did not correspond to what was taught in the class and what was discussed at the meeting. The lesson plan presented in Appendix 15 revealed Lenox’spoor content and pedagogical knowledge. His lesson presentation was not fully aligned to the curriculum requirement due to the absence of laboratory apparatus to conduct the practical demonstration. This was a deficiency in the required pedagogical knowledge for this specific lesson. Lenox continuously read directly from the textbook during the teaching process. This was an indication that he was not fully confident in teaching this specific lesson. Lenox was observed using various teaching methods to clarify learners understanding of the lesson. He encouraged learners to always ask questions on what they don’t understand as his office is always open for explanation.

4.7.2 Mbali’s first lesson presentation

The physical sciences period for Mbali’s first lesson commenced at 11:30 and ended at 12:10. Her first lesson was on the magnetic field associated with a current. She welcomed the learners to the class and introduced the researcher to the learners. She offered the researcher a seat at the back of the class. She introduced the lesson by writing the topic (electromagnetism) on the board. Mbali reproduced learning materials by distributing photocopies of class activity pages and textbook pages to all the learners. During her lesson introduction she said:

> *Now we will be looking at how the interaction between current, charges, electric field and the magnetic field is being established, but before proceeding it is very important for you to know that an electric current will always create a magnetic field and a change in the magnetic field creates a flow of charge. (Mbali).*

She immediately assessed her learners’ previous knowledge by asking them to define a magnet and state the different types of magnet. A learner responded by saying “a magnet is an iron substance with a property of attracting another substance to itself*”.* During the question and answer session, some of the learners behaved unruly by dragging their feet on the ground as they entered the class. This disruptive behaviour interrupted the learning process as other learners in the class started laughing. It seems that Mbali lacked class discipline skills. Mbali continued her teaching by asking learners to mention the types of electricity. One of the learners answered the question by reading from his notebook while another learner answered the question from memory. Mbali explained how electricity and magnetism are related using a solenoid, galvanometer and a compass as examples. She said:

> *"Experiment on this topic will not be possible because there is no apparatus in the laboratory."*

She used examples from the textbook to further explain the concept of galvanometer and solenoid. She asked the learners to imagine the deflection of the galvanometer from the examples illustrated in their text material. Mbali stated the right-hand rule by reading from the textbook. During her explanation, she indicated that the right-hand rule is the only method that can be used to determine the direction of a magnetic field around a current carrying conductor . She demonstrated the right-hand rule using her hand as agreed during the lesson planning meeting. Learners were given class activities from their workbook. However, they could not answer the class activities correctly using the illustrated right-hand rule concept. The bell went off at exactly 12:10 and the teacher encouraged learners to try to practice the questions in their workbook to enable them to understand the concept better. A picture of Mbali teaching theconcept of electromagnetic induction to learners is shown in Figure 4.4.

Figure 4-4: Picture of Mbali using the lecture method when teaching electromagnetism

4.7.2.1 Analysis according to observation schedule

The data collected when observing teachers' lesson was analysed based on the requirements outlined in the observation protocol provided in Appendix 11. These components included assessment of learners learning, instructional delivery, classroom interaction and teacher's knowledge.

Assessing learners learning

During the first lesson observation, Mbali assessed learners' previous knowledge of Grade 10 electricity and magnetism by asking the learners to explain what a magnet was and also to state the different types of magnets. This approach was also used as a method of introducing the new lesson to learners. She assessed learners' understanding by asking the learners to use the right-hand rule to determine the direction of the magnetic field for the diagrams illustrated in their photocopied textbook.

Instructional delivery

Mbali presented an overview of what the lesson entailed when she said "now we will be looking at how the interaction between current, charges, electric field and the magnetic field is being established. It seemed that Mbali believed that learners already knew the meaning of words like electric field, magnetic field, current, and charges; so, she did not explain any key terms or unfamiliar terms. In her lesson, she used a variety of examples as illustrated in the textbook to clarify concepts on electromagnetism. However, it was observed that Mbali did not integrate real-life illustrations in her teaching. The researcher had expected Mbali to show more interest while teaching the topic since major difficulties had been discussed during the planning meeting. Rather it was observed that Mbali was not passionate about the lesson, she only did the lesson as required and expected in the curriculum. It seems that Mbali had the same perception about the unimportance of the topic as her colleague because learners are not assessed on this topic at the matric level. So, teachers don't really show much interest when teaching this topic. She also did not borrow equipment as discussed in planning. Learners in Mbali's class were noisy during the lesson delivery and all efforts to keep learners attentive during her teaching proved abortive since the learners were disobedient and uncontrollable.

Classroom interaction

According to the curriculum, learners are to observe the magnetic field around a current carrying wire. This practical activity will give learners the opportunity to work together and discuss their observations. However, Mbali did not engage the learners in any form of small group activity or practical collaboration due to the absence of laboratory equipment. Mbali used the lecturing method in explaining practical activities and key concepts that learners needed to understand. Mbali involved learners to participate when she asked specific questions and instructed learners to signify by raising their hands if they knew the answer. She supported the learners by encouraging them to practise more questions in their workbook to enable them to understand the concept better. Mbali did not have control over her class since she was unable to give a thorough order or reprimand the learners for their disruptive behaviours. Though Mbali asked questions during the teaching, she did not encourage the learners to ask questions. This made the classroom interaction one sided.

Teacher's knowledge

Mbali presented the specific knowledge required for teaching the lesson in detail and explained the content as planned during the planning meeting, but different from the written plan submitted by Lenox. Though she did not give the learners notes to write she gave a correct explanation of basic concepts covered in the topic. She also demonstrated her pedagogical skills when she used her right hand to illustrate a simple way how learners could indicate the direction of flow of current in conductors and the direction of the associated magnetic fields. This showed that her collaboration with her colleague has improved her content knowledge as compared to her response during the interview when she said:

> *"This concept of a magnetic field associated with current carrying wires.... iyooooo it is confusing to learners and even to some educators." (Mbali).*

Mbali did not pace the lesson appropriately probably due to her nervousness and it would have been the first time she opened her class to visitors. It seems that Mbali was not confident teaching this topic because there were situations where she constantly paused during her teaching to refer to her notes and textbook for clarifications. This could be because of her nervousness due to the presence of the researcher in her class.

4.8 Second Lesson Study meeting

4.8.1 First reflection session by pair A

The second Lesson Study meeting was a debriefing and planning session which was held on Friday, the 9th of September 2016. Teachers could not observe each other's lesson as explained in Chapter 3. So, all lesson presentations were recorded by the researcher as explained in Section 3.7.2 and an observation checklist was used to gather data on each teacher's teaching and their learners' responses. Both teachers were given the opportunity to watch the video of their colleague's lesson. After this they reflected on what happened during their lesson and discussed the challenges they encountered. In order to have a better understanding of the observed lessons, teachers were given the used observation checklist. Teachers aligned the checklist to their reflection on what happened during their teaching and discussed issues identified on the list. Mbali revealed that she has never had any visitor in her class while teaching. Mbali said: "*I am not used to this situation where somebody else is in your class when you are teaching……and you know your presence got me distracted at first, although I think now you saw the learners' behaviour which I had earlier told you about during the interview."* It seems Mbali believes that she was exposing her class to a total stranger. She indicated that she needed to work on her class management and discipline skills for future lessons. Lenox believes that not involving learners in his class teaching was a bit problematic when he said: "*I did not really call out learners to solve problems on the board and I think I need to improve on that practice because it will help build my learners confidence in answering questions".* During the debriefing process, the teachers discussed how to create an opportunity for small group activities among their learners. This included giving questions that allowed learners time to think, pair and share their knowledge, and also allow for the clarification of key concepts using relevant activities, writing out of keywords when teaching, logical presentations of lessons and checking learners' ability to understand the lesson within the stipulated lesson period. The teachers also asked the researcher to assist with clarification on specific questions relating to the direction of magnetic fields when connecting a solenoid to a galvanometer. Learners' reactions to questions and responses as observed from the video provided insight on how teachers need to revise and re-teach the lesson if they have the opportunity. After reviewing their reflections and discussions about their first lesson, teachers agreed to emphasise the following whenever they are to teach the lesson again: learners' increased participation, use of likely examination questions on the direction of magnetic fields and determining the direction of a field using a solenoid. Lenox stated that unfortunately, the reviewed discussions on the lesson will only be implemented when teaching the new set of learners in the next academic year, but the researcher mentioned that suggestions should be adopted in planning another lesson. So, Lenox indicated that further lessons can be improved if teachers could call out a few learners to solve questions on the board and also provide time for class discussions among learners. Teachers' suggestions from the first lesson were used to plan a new lesson on Faraday's law.

4.8.2 Second planning session by pair A

Teachers were asked to use their experience from the first planning session to plan the other two research lessons. During the second meeting, Lenox indicated that the whole idea of Faraday's law is to explain how learners can use calculations in relating the electromotive force produced by the magnetic flux around a loop of conductors. He further mentioned that the best way to explain such concepts was by stating Faraday's law and mathematically expressing it. He indicated that the meanings of each mathematical representation needed to be fully explained. Mbali elaborated on the need to do a lot of examples using calculations on the topic since learners have a problem with calculations. Mbali also said that looking at the curriculum there is need to explain what happens to a magnet when pushed into or pulled out of a solenoid connected to an ammeter . She stated that this was supposed to be a practical class but since the school does not have apparatus, teachers will only explain the concept to learners and hope they understand properly. Lenox suggested the following during the planning section.

> **Lenox:** *"I think we can draw a diagram of the magnet going into solenoid connected with an ammeter on the board. Using such illustration could further enhance learners understanding and imagination to some extent."*

The teachers discussed the examples and explanations that needed to be done in the class. One such explanation was the possibility of magnetic flux being zero when the magnetic field is not zero . Lenox, being an experienced teacher, said that the relationship between a magnetic flux and magnetic field is always given as $\phi = BAcos\,\theta$. In Lenox's explanation, he stated that if the value of $\cos\theta$ is given as zero, the magnetic flux will become zero either in the presence or absence of a magnetic field. According to Lenox, this will allow the magnetic field to be on the same level with the surface which does not allow any passage through it. A summary of the lesson content and lesson plan presented by the teachers is provided in Appendix 15. Analysis of the lesson plan indicated teachers' incorrect use of vocabulary words and inadequate language command. More so, teachers did few examples on problem-solving, which was given to learners in the class. During the problem-solving, the researcher assisted teachers in clarifying some difficult concepts. An example from the problem-solving questions that teachers planned during the second Lesson Study planning session is shown in Figure 4.5.

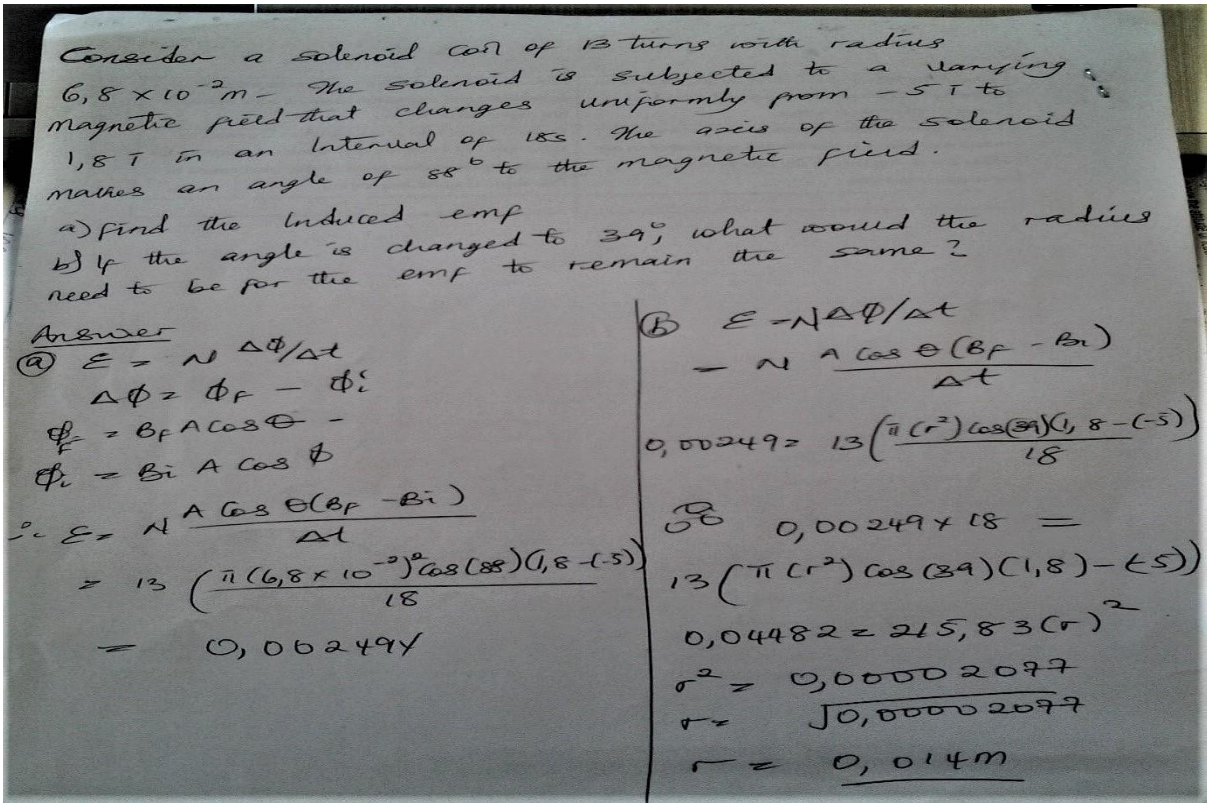


Figure 4-5: An example of problem-solving on Faraday's law of electromagnetic induction planned by pair A during the second planning session.

4.9 Classroom observation for the second research lesson

4.9.1 Lenox's second lesson presentation

Lenox's second lesson presentation was on Faraday's law of electromagnetic induction. Lenox welcomed the learners to the class and revised the previous lesson with the learners. After the revision, he indicated that the aim of the new lesson was to determine the strength of a magnetic field, solve problems on magnetic flux and Faraday's law. Lenox gave a detailed explanation on how learners can determine the direction of magnetic fields using likely examination questions. He gave a brief explanation on the importance of the topic to the learners' environment. After the explanation, Lenox referred the learners to page 243 of their photocopied textbook for a better clarification of his explanation on magnetic poles based on the previous lesson.

Lenox described the induction by explaining what happened when a magnet is pushed into a solenoid connected to an ammeter. As the teaching continued, Lenox engaged the learners in a group discussion on how the number of windings in a solenoid affected the deflection in the ammeter. After few minutes, he called two learners (A1 and B1) to explain their answers. Both learners responded by saying "The number of windings in a solenoid is inversely proportional to the magnetic field". Lenox corrected the learners and indicated that the "Higher the number of windings in the coil, the greater the deflection on the ammeter". Lenox asked learners to pay attention closely to his explanation since he could not get copies of the photocopied textbook page. Lenox explained the concept of magnetic field strength in Tesla and the learners shouted which seemed to be an indication of their reaction to the pronunciation of the word 'Tesla'. Lenox further explained the concept of magnetic flux and drew a diagram on the board showing the orientation of a surface in relation to the magnetic field. Lenox continued his teaching by presenting Faraday's law directly from his textbook. He gave a mathematical representation of the law as $E= -N\ ^{\Delta}\phi/\Delta t$. He wrote down the meaning of each mathematical terms on the board. Lenox indicated that Faraday's law showed the relationship between induced electromotive force and the rate of change of flux. So, he explained the mathematical presentation of the law as the product of the magnetic field and the cross-sectional area which the field lines pass through . Lenox solved few examples of Faraday's law and asked learners to take down the given examples in their notebook. As learners were writing down the examples, one of the learners asked: "Why is there a negative sign on the mathematical representation of the Faraday's law?". Lenox responded by saying "the sign indicates the direction of the current which opposes the direction indicated in the right-hand rule" and all the learners sighed which indicated that they probably did not understand. Lenox's explanation is unclear, suggesting that Lenox himself has a poor understanding of Lenz's law. (The negative sign indicates direction and it implies that the induced emf tends to oppose the change in magnetic flux). Lenox engaged learners in a class activity on calculations involving Faraday's law. During the class activity, Lenox observed that some of the learners were busy talking. He interrupted their discussion by calling two of the disruptive learners to provide the answer on the board. Both learners got the answer wrong, so Lenox solved for the correct answer on the board. Lenox continued his teaching by explaining the rate of change of magnetic flux as ($\Delta\phi$ = (ϕ_f - ϕ_i) i.e. the difference between the final magnetic flux and the initial magnetic flux. Lenox engaged learners in a series of class activities. He called out two of the learners to solve their answers on the board. Both learners answered the questions correctly. The bell rang indicating the end of the lesson period and Lenox promised to solve more examples before giving homework since some learners were still struggling with the mathematical concept involved in magnetic flux and Faraday's law. A picture from Lenox's lesson on Faraday's law is shown in Figure 4.6.

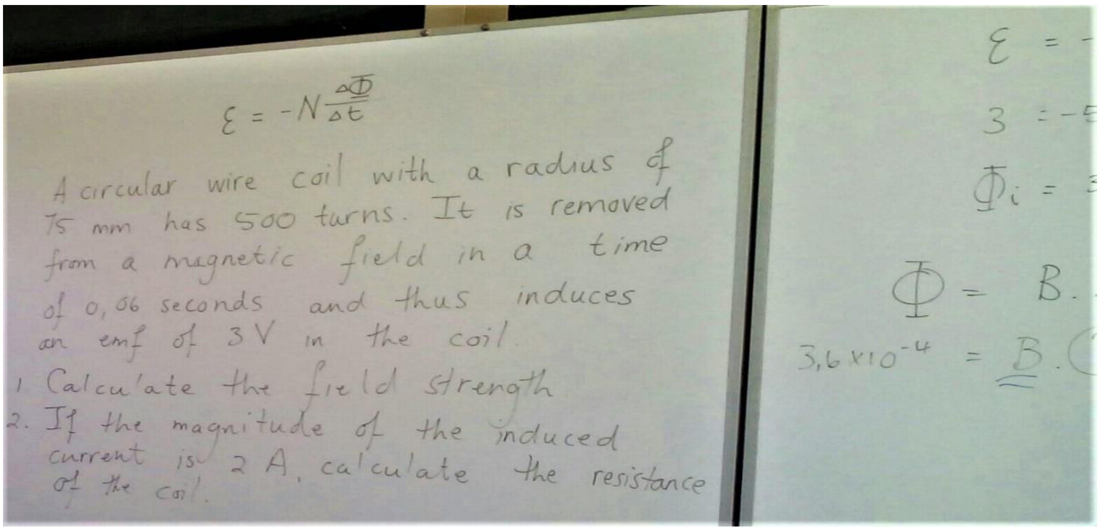


Figure 4-6: Example from Lenox's lesson on Faraday's law

4.9.1.1 Analysis according to observation schedule

Assessing learners' learning

Lenox engaged learners in a class discussion by asking them to open their photocopied textbook page, read a particular activity and explain what happened between the number of windings in a solenoid and the direction of the magnetic field. According to Lenox, this activity was based on a learner's question in his previous class.

Instructional delivery

During Lenox's second lesson delivery, he presented an overview of the lesson and also outlined the lesson objectives. Lenox used teaching strategies like diagrams and explanations in achieving the goals designed for the lesson. Though he attempted to clarify learners' difficulties on magnetic flux and Faraday's law, his explanations were inadequate. This was observed when a learner asked for clarification on the negative sign used in the mathematical representation of Faraday's law which Lenox did not conceptually explain. Lenox also used a problem-solving approach in enhancing learners understanding of Faraday's law. He did a lot of examples and also used learners' participation as a way of teaching his lesson. It was interesting to see that Lenox enjoyed teaching this topic because he was always focused on the examples and tried as much as possible to ensure that the learners understood the calculation aspect of the lesson.

Classroom interaction

During Lenox's second-class observation, there was an improvement on his use of learners' participation in his class teaching. He supported the learners by giving a series of class activities and reinforcing them to answer the questions on the board. Lenox encouraged individual and independent work among his learners by engaging them in problem-solving activities on Faraday's law. The teacher was also observed making effective gestures, pauses, and silences during the teaching and learning process. This gave the disruptive learners an opportunity to listen to what their classmate was explaining. Lenox encouraged learners to ask questions and he was willing to answer though his explanations were not always clear. He also demonstrated his ability to improve learners' listening skills when he saw some learners talking during the class-activity and he immediately acted by calling them out to solve the activity on the board.

Teacher's knowledge

Lenox presented and explained the content of this lesson in detail. He demonstrated his knowledge of various teaching skills during the lesson delivery. He used a lecture method approach in explaining the concept of magnetic field strength. He also explained the concept of Faraday's law on the board using mathematical representation and a brief explanation of terminologies used. Learners in this class asked questions related to the content of the lesson. Other pedagogical skills demonstrated by Lenox during the lesson delivery include engaging learners, classroom management, addressing learners' difficulties and providing feedback to learners. Lenox did not assess learners' previous knowledge before teaching the second lesson, but he revised the previous lesson with the learners. This was done in order to establish the relationship between the magnetic effects of current and Faraday's law so the learners would not see the topic as a different one

4.9.2 Mbali's second lesson presentation

Mbali's second research lesson was on Faraday's law and was presented on a Wednesday, between 12:00 and 12:40 p.m. She asked the learners to pay attention indicating that she was not going to repeat any explanation if learners did not behave well. Mbali assessed learners' knowledge on how to check the direction of the field around a straight conductor. Learners responded by saying "You use the right-hand rule". Mbali revised the concept of magnetic field around a straight wire and around a current carrying loop using Setswana language and later switched to English. She asked two of the learners to demonstrate the concept of a magnetic field of a circular conductor carrying current. One of the learners used a paper to demonstrate and explain the concept of "in page" as shown in Figure 4.7.

Figure 4-7: Learners in Mbali's class demonstrating magnetic field of a circular conductor carrying current.

During the demonstration, Mbali asked the two learners to draw the diagram of what they have demonstrated on the board showing the directions with arrows. Both learners got the diagram correct. One of the learners indicated that the thumb indicates the current while the curled fingers indicate the direction of the field.

Mbali introduced her lesson on induction by drawing the diagram of a magnet and its field direction on the board. Learners were requested to identify the North and South Pole from the diagram. Mbali explained the diagram by indicating how the needle of an ammeter deflects in one direction when a magnet is pushed into a solenoid connected to an ammeter and deflects in the opposite direction when the same magnet is pulled away from the solenoid. She continued her teaching by explaining how learners can find the direction of the induced current using the magnetic field around a solenoid. She said,

> *Current can be induced when a magnet is fixed at a position and the solenoid is moved forth and back within the magnetic field. However, the induced current generates a magnetic field in a direction that tends to oppose the change in the magnetic field in the solenoid. So, the Right-Hand Rule can be used to find the direction of the induced current by remembering that the direction of induced current will create a magnetic field that opposes the change in the magnetic flux. (Mbali).*

Mbali assessed learners knowledge of Faraday's law. One of the learners responded by saying: "The induced emf is directly proportional to the flux in the magnetic field". Mbali reviewed the learner's definition of Faraday's law when she wrote the mathematical representation on the board as $E= -N\ ^{\Delta}\phi/\Delta t$. Mbali explained the law when she said: "The induced emf in a conductor is directly proportional to the rate of change of magnetic flux". She also explained magnetic flux as the number of field lines that pass perpendicularly through an area (A) or the conductor (e.g. circular loop). Mbali assessed learners' understanding of the formula in the following conversation.

> **Mbali:** *What is the meaning of the negative sign on the mathematical representation of the law?*
>
> **All learners:** *Direction*.
>
> **Mbali:** The *direction of what*?
>
> **Learner 1:** *The direction of number of coil*
>
> **Learner 2:** The *direction of the current*.

Mbali explained the meaning of the negative sign as the direction of the induced emf and the learners all said, "*okay".* However, she did not relate her explanation to Lenz's law. She then assessed learners' understanding of emf. One of the learners responded by saying "electromagnetic field", while another learner said, "electromotive force". Mbali indicated that the only way learners can determine the direction of currents and associated magnetic fields is using the right-hand rule. She said:

> ***Mbali:*** *Always remember that if the finger of your right hand is pointing in the direction of the current, then your thumb points in the direction of the magnetic field. But if your thumb points in the direction of the magnetic field, then your finger is pointing in the direction of the current.*

She involved the learners in a few class activities and provided feedback on the class activities. As the teaching continued, Mbali explained the relationship between magnetic flux and magnetic field as $\phi = BA\cos\theta$. She explained each term indicating that A represents the surface area, B represents the strength of the magnetic field and ϕ is the magnetic flux. She explained how the magnetic flux becomes zero when the magnetic field is not zero. She went further to explain how learners can determine the magnetic flux when given the angle between B and the perpendicular normal on the surface solving three examples of when θ equals 0^{o}, 60^{o}, and 90^{o}. Learners were unable to provide answers from their calculators during the problem-solving activity. Mbali encouraged the learners to learn how to use their calculators for future purposes. A learner asked the teacher to re-explain the relationship between a magnetic field and the direction of angles. The bell rang before Mbali could start re-explaining the concept. She concluded her lesson saying, “I think you are still struggling on how to differentiate between parallel and perpendicular angles, so I hope to explain it again at our next meeting”.

4.9.2.1 Analysis according to observation schedule

Assessing learners learning

During the second lesson presentation, Mbali assessed her learners’ previous knowledge by engaging the learners in a question and answer section. This teacher directed question and answer approach created an opportunity for her to involve the learners in class discussion. This was observed when she asked the learners to explain how they can determine the direction of the field around a conductor. It seems Mbali intentionally asked this question to have a general view of learners’ understanding on the topic and also to adjust the pace of the lesson. During her teaching, she constantly asked questions to assess learners understanding of the lesson. Mbali’s assessment of learners’ understanding and remembering is another method of evaluating the level of learners’ academic work.

Instructional delivery

The researcher had expected Mbali to practically demonstrate the application of Faraday’s law so that learners could visualise what happens when a magnet is pushed into or pulled out of a solenoid connected to a galvanometer. However, she only used words and diagram in describing this concept to the learners since the school does not have the practical equipment required to teach this concept as outlined in the curriculum. Mbali used her pedagogical skills to achieve the outlined goals of the lesson. She used mostly explanations during her teaching. This was observed when she briefly explained how learners can determine the direction of the induced current in a solenoid using the right-hand rule. Mbali also used several worked examples to enhance learners’ understanding of problem-solving activities.

Classroom interaction

Mbali actively engaged the learners in the teaching and learning process. It was observed that Mbali allowed the learners to comprehend and incorporate themselves into the learning process by constantly asking them questions relating to what she was teaching. This also helped her in monitoring learners' understanding, even though she did not give the learners sufficient time to respond to some questions. This could be due to time constraint since she indicated that she had to immediately attend to Grade 12 learners in preparation for their matric. Mbali also empowered the learners by engaging them in class activities and she provided feedback to learners based on the class activities. It was interesting to observe how Mbali provided support for the learners. This was observed when she carefully listened to the learners' questions and used those questions in an attempt to guide them through the teaching process. It can be concluded that Mbali demonstrated a good communication relationship with her learners as she also encouraged independent work among her learners through the class activity.

Teacher's knowledge

The content of Mbali's lesson presentation explicitly covered the content as prepared during the second planning session. The content of her lesson was mostly correctly presented. There was no provision for collaborative activities in terms of practical work. However, learners were involved in problem-solving activities. It seems her method of assessing learners' previous knowledge also created an opportunity to identify their difficulties from previous lessons. Mbali demonstrated some skills which were not observed during her first lesson delivery. These skills included learners' participation and her ability to ask questions that promoted learners' thinking and reasoning skills. Mbali also encouraged learners to ask questions, by verbally asking them if they understood the lesson. Though she was able to teach learners how to make use of Faraday's law, her explanations were not on a conceptual level. This showed that Mbali lacked in-depth understanding of the phenomenon.

4.10 Third Lesson Study meeting

4.10.1 Second reflection session by pair A

The third Lesson Study meeting was held on Thursday, September 15. The meeting started as the researcher encouraged the teachers to focus on the positive side of their participation in the study. While teachers watched the recorded videos of their second lesson presentations, they made comments on their observations and experiences while participating in the Lesson Study process. Mbali complained about the time spent and how tired she gets at the end of the lesson planning section. She also mentioned that learners' reaction and attitude to class activity is gradually improving as compared to what normally happens in her class. Lenox indicated there are some learners who don't understand the use of the thumb and the direction it indicates. Mbali suggested that teachers should keep encouraging learners to practise as many questions as possible, since time is not on their side. The researcher then requested that they point out any problems observed during their second lesson presentation. Lenox indicated that learners were still struggling with the application of mathematics in problem-solving. Mbali indicated that the problem is a general one which needs the assistance of both physical sciences and mathematics teachers. Lenox mentioned that calling out learners to solve questions on the board has been quite helpful in building the learners' confidence and ability to stand in front of the class. However, he complained that the time allocated to the lesson period is not sufficient. Mbali suggested that giving learners homework on a regular basis could also help but marking it will be a big challenge for her because of her workload and class size. The researcher requested that they note down the problems and suggestions they had mentioned. Teachers were encouraged to develop other ways of assessing their learners' learning as they use suggestions from their reflection to improve future lessons. After the debriefing session, the teachers planned their next research lesson on electrical circuits.

4.10.2 Third planning session by pair A

Lenox agreed to write down the lesson plan using the Lesson Study plan guide they were given while Mbali summarised the overall goal expected in the lesson. Figure 4.8 shows one of the planning meetings by Lesson Study pair A.

Figure 4-8: Lenox and Mbali working together as a pair during their Lesson Study planning meeting.

During the brainstorming session on learners' challenges in this topic, teachers indicated that learners don't understand how current flow in a series and parallel circuit, how to calculate or solve problems on the combination of circuit, Ohm's law, and power. Lenox and Mbali agreed to assess learners' previous knowledge on the types of circuit, the concept of current, resistance, and voltage from their grade 10 lesson. They agreed to carry out a simple practical demonstration with the learners as outlined in the curriculum. Teachers indicated that learners are expected to explain their observation during the practical demonstration, as they connect resistors in series and parallel using a mini circuit. Lenox suggested that there is need to explain the application of Ohm's law in terms of Ohmic and non-Ohmic resistors. Mbali stated that calculations involving simple series and parallel circuits should be properly addressed and learners' response would determine how they proceeded to the introduction of complex circuits. During the planning stage, the teachers outlined basic formulas that learners needed to understand before they could proceed to problem-solving on the electrical circuit. A representation of the outlined formulas Lesson Study pair A agreed to explain and use during the calculations involved in the electrical circuit is shown in Table 4.4.

Table 4-4: Important formulas outlined by Lesson Study pair A during their third Lesson Study planning meeting.

$V=IR$	$P = \Delta E / \Delta t$	$P=I^2 R$
$P=VI$	$P=V^2/R$	

Mbali suggested that learners should be guided on how to simplify complex circuits by redrawing such circuits after solving the equivalent resistance within the circuit. They both jointly solved a few activities for learners and clarified difficult calculations that might be confusing to learners. Mbali indicated that learners don't know how to solve equations with more than one variable. Learners also don't understand that they need to use an inverse method when solving for parallel circuits. The researcher encouraged the teachers to take note of the concepts/points mentioned as they teached in their respective classrooms.

4.11 **Classroom observation for the third research lesson**

4.11.1 Lenox's third lesson presentation

The third lesson presentation was on electrical circuits. He used a lecture teaching method. Lenox presented a series of basic definitions, key concepts, and principles that learners must understand before engaging in problem-solving tasks on electric circuits. He assessed learners' previous knowledge on the electric circuit by asking them to state Ohm's law. One of the learners read the answer directly from her book while the other learner gave the mathematical representation of the law as V=IR. All learners were requested to know how to state Ohm's law since it's paramount to their understanding of whatever needs to be done in electricity. Learners were asked to give examples of equipment that consumes electricity in their respective homes. They responded in their home language (Tswana). Lenox instructed the learners to speak English when answering other questions. As the teaching continued, Lenox wrote the mathematical expression of Ohm's law on the board as $I \alpha V/R$. He integrated real-life applications into his teaching. This was observed when he explained how learners consume electricity in their homes through resistors in their bulbs, televisions, sound systems, refrigerators and whatever other equipment they have in their houses. Lenox used diagrams and tabular representations to explain potential difference and current in a circuit when resistors are connected in series and parallel respectively. Lenox suggested that that when learners are solving questions on combined circuits, they should first re-arrange the circuits by differentiating the parallel connection from the series connection and solve them separately before bringing them together with their respective answers to solve for the final answer. As the teaching continued, Lenox asked: “How do you arrange a voltmeter in a circuit?”. One of the learners responded by saying “Voltmeter is arranged in parallel since it’s having a high resistance”. Then Lenox indicated that an ammeter is always connected in series since it has the lowest resistance. Learners were engaged in a written class activity to assess their understanding of the lesson. Lenox drew a circuit diagram on the board and instructed learners to write down the following question which he read from a textbook.

Lenox: A *switch box is opened*

1. *Determine the reading on the ammeter,*
2. *Determine the reading on V_1, now the switch is closed,*
3. *Calculate the total resistance (R_T) of the circuit,*
4. *Determine the reading on V1,*
5. *How much charge will pass a current in the 8-Ohm resistor within 2 minutes?*

As learners attempted the class activity, Lenox went around to check learners’ work. This gave him the opportunity to have a better understanding of how learners learn. Lenox spent about seven minutes reprimanding one of the learners who did not attempt the class activity. Learners could discuss and share their answers with one another. Thereafter, one of the learners was required to write the solution from her note on the board as shown in Figure 4.9.

Figure 4-9: One of the learners in Lenox's class solving question on the board

It seems this was done to build learners' confidence and problem-solving skills. Lenox used learners' answers as a guide in providing corrective feedback to the class activity. Learners were given the opportunity to write the corrections in their book, after which Lenox explained the difference between potential difference and electromotive force in a circuit. In his explanation, he indicated that when a switch is opened, the voltmeter will always show a particular value which is called the emf (electromotive force) value but when the switch is closed the emf value will drop and the value indicated by the voltmeter becomes the potential difference (PD). As the teaching continued, Lenox observed that learners were still struggling with interpreting questions and the application of the mathematical formulas in solving parallel arrangements. He pointed out that instead of finding the reciprocal when using parallel equations, some of the learners solved the question directly by using the formula for a series connection. Lenox concluded his lesson by telling the learners to keep on practising different activities since practise makes perfect.

4.11.1.1 Analysis according to observation schedule

Assessing learners learning

After writing the topic on the board, Lenox assessed learners' previous knowledge from their Grade 10 class by asking them to state Ohm's law. He also assessed their previous knowledge by engaging them in a class discussion. This was observed when he told the learners to give examples of equipment that consumes electricity in their respective homes. This was a discussion lead by the learners. More so, when he gave the learners class activities he asked them not to ask questions from anybody to avoid noise or disturbance in his class. Lenox also assessed learners' learning by checking for learners' understanding when he drew a circuit diagram on the board and asked the learners to re-arrange the diagram.

Instructional delivery

During Lenox's presentation, the researcher observed that the lesson was not fully aligned to the objective outlined in the curriculum and in the Lesson Study plan. The reason was because he did not conduct the practical demonstration that was agreed upon during the planning session. When presenting the lesson, he ensured that learners' difficulties on the definition and difference between potential difference and electromotive force were clearly explained. Lenox demonstrated his knowledge of various instructional practices in teaching this lesson. The skills include lecture presentation, explanation, question and answer, eliciting learners' previous knowledge and calling learners to answer questions on the board. He also integrated examples from real life experience into his teaching. This was evident when he explained how the electrical appliances used in learners' homes consume electricity produced by Eskom. Lenox emphasised the importance of Ohm's law to these Grade 11 learners even though they should know the concept of Ohm's law from their Grade 10. Lenox also clarified key concepts involving resistance, current, and voltage of a parallel and series circuit through diagrams, tabular representation and relevant activities using problem-based learning. He asked the learners to identify electrical equipment amongst themselves in groups, and select a representative who will share their answers with the whole class. It seems this approach assisted Lenox in managing the disruptive behaviour of the learners.

Classroom interaction

Lenox presented facts about the application of electricity in real life situations and he supported his points by using lecturing, re-teaching, problem-solving and explanation method as a means of passing knowledge to the learners. Learners understood their teacher's behavioural expectation, so they were obedient to their teacher's instruction.

This gave Lenox the opportunity to effectively manage the class, as the teacher and learners demonstrated mutual respect. Lenox demonstrated his classroom management skills by proficiently handling unexpected classroom situations. Lenox often switched languages during his teaching. This was noticed when learners were mentioning home equipment that consumes electricity and Lenox's explanation on how electricity is consumed in their homes. This concept was explained by the teacher and learners both in English and Setswana and it seems this gave Lenox the opportunity to relate well with the learners. Lenox encouraged individual/independent work among learners when he dictated questions from his personal notes and asked all the learners to write down the question in their notebooks. His management of interaction was also demonstrated when he used learners' responses to class activities as a guide in providing the correct answers to questions asked. It seems this was his own way of supporting learners' learning. He also created an environment of interest for the learners by giving them the opportunity to share answers, ideas, and knowledge with one another. It seems Lenox was always having his learners in mind and tried to develop ways in which he could encourage them to participate in the teaching and learning process. This was observed when he asked questions that promoted learners' problem-solving skills and motivated learners to answer all questions asked during the lesson.

Teacher's knowledge

The content of Lenox's lesson was presented according to the purpose outlined in the curriculum and was also appropriate for the learners' academic level. This was observed when he explained what happened to the voltage and current when resistors were connected in series and parallel. His lesson was logically presented and appropriately paced. It seems that Lenox demonstrated command and accurate knowledge of the subject matter. He related the content of the lesson to learners' Grade 10 knowledge on resistors in series and parallel. However, Lenox did not engage learners in practical activities that supported his lesson as planned during the Lesson Study planning session. During his teaching, he demonstrated commitment and enthusiasm about the lesson and learners' learning when he showed learners the step by step method that can be used in rearranging a complex circuit into a single circuit. It seems Lenox really showed interest in teaching this topic by re-teaching the concept of a complex circuit to the learners when he observed that learners were struggling with how to resolve the complex circuit. Lenox also demonstrated his knowledge of learners' academic interest by providing learners with accurate feedback on questions asked during the lesson. This was observed when he solved questions from class activity on the board and explained the step by step process of how learners can arrive at the correct answers. Lenox also used a tabular representation to explain key points on what happens to the current and potential difference for resistors connected in series and parallel.

4.11.2 Mbali's third lesson presentation

The third lesson was on electrical circuits. Mbali wrote the topic on the board and distributed photocopies of the learning materials to the learners. She assessed learners' previous knowledge based on Grade 10 physical sciences work through the next conversation.

> **Mbali:** *What are the different types of electricity?*
> **Learners:** *Static and current electricity.*
> **Mbali:** *Okay so what is meant by static electricity*"?
> **Learner 1:** S*tatic electricity is that electricity which has no motion of charges.*

Mbali explained the concept of static electricity and assessed learners' understanding of current electricity. None of the learners responded and the teacher repeatedly mentioned the opposite of static electricity. Then a learner responded by saying current electricity means electricity that has the flow of charge. Learners were requested to raise their hand whenever they wanted to answer a question. Mbali explained electrical current as the amount of charge that flows past a point every second. As the teaching continued, oral questions were used to assess learners' prior knowledge on types of circuit and components of the electric circuit. Learners mentioned series and parallel circuit as types of circuit. Mbali indicated that there is the open and closed circuit. She described the open circuit as a broken circuit which does not allow the continual flow of electrons and the closed circuit as a circuit which allows the continuity of electron flow. She invited a group of learners to the front of the class for a practical demonstration on how to connect resistors in series and parallel using a circuit board as shown in Figure 4.10

Figure 4-10: Group of learners in Mbali's class performing an experiment on electric circuit

The teacher guided the learners in identifying basic components on the circuit board as she explained the connection process. The group of learners was later requested to do the connection on their own and explain their observation. During the practical demonstration, learners explained the brightness of the bulb as observed. However, they could not differentiate if the connection was in series or parallel. Mbali explained to the learners that "light bulbs connected in series have the same current but share the voltage across the circuit so each bulb will have a lower voltage which will cause the bulb to glow dimmer. On the other hand, in parallel connection the voltage across each bulb is equivalent to the voltage of the battery and the current flowing through each bulb is determined by V=IR". Mbali seems to have avoided the conceptual teaching and interpretation of effective resistance in her explanation. She explained the meaning of key terms associated with the electric circuit and solved few problem-solving examples on the board. After Mbali's solved examples, learners were given a class activity from their textbook. After a few minutes, she asked the learners to provide answers to the question. Mbali observed that none of the learners answered the question correctly. So, she used a tabular representation shown in Table 4.5 to further enhance learners understanding of resistors connected in series and parallel.

Table 4-5: Tabular representation of Mbali's summary on series and parallel connection

Resistors connected in Series	Resistors connected in Parallel
Current is the same	Current divides
Voltage divides	Voltage is the same

Learners were attentive and repetitively echoed "okay" to confirm that they understood the teacher's explanation. Mbali continued her teaching by using Ohm's law to explain the relationship between resistance and voltage. As the teaching continued, verbal questions were used to assess learners' knowledge of Ohmic and non-Ohmic conductors. Learners were asked to state the mathematical formulae for Ohm's law. They responded by saying V=IR. Mbali explained the relationship between V and R, as "directly related or proportional to one another which implies that as the resistance increases the voltage increase and as the resistance decrease the voltage also decreases". Her response reveals her understanding of the mathematical interpretation of Ohm's law, but is a poor explanation on the cause and effect of Ohm's law in a physical circuit. (Ohm's law states that the current in a circuit is directly proportional to the voltage {V α̣̇ I}, removing the proportionality sign implies that V=RI where R is the proportionality constant. This implies that the current in the circuit is inversely proportional to the resistor). Next, Mbali explained the difference between electromotive force and potential difference. She indicated that "emf comes from the source (battery) when the circuit is opened while the given voltage is the potential difference which is the work done by the battery". Her explanation of potential difference was not totally correct. Potential difference is the work done when a coulomb of charge passes between two points. She did a few examples of series and parallel circuit problems and gave learners a class-activity involving calculations on the circuit. After few minutes, Mbali wrote corrections to the class-activity on the board as shown in Figure 4.11. The bell for the next period rang and Mbali concluded her lesson by encouraging learners to always substitute correctly. She instructed learners to practise other questions in their activity book until the next class.

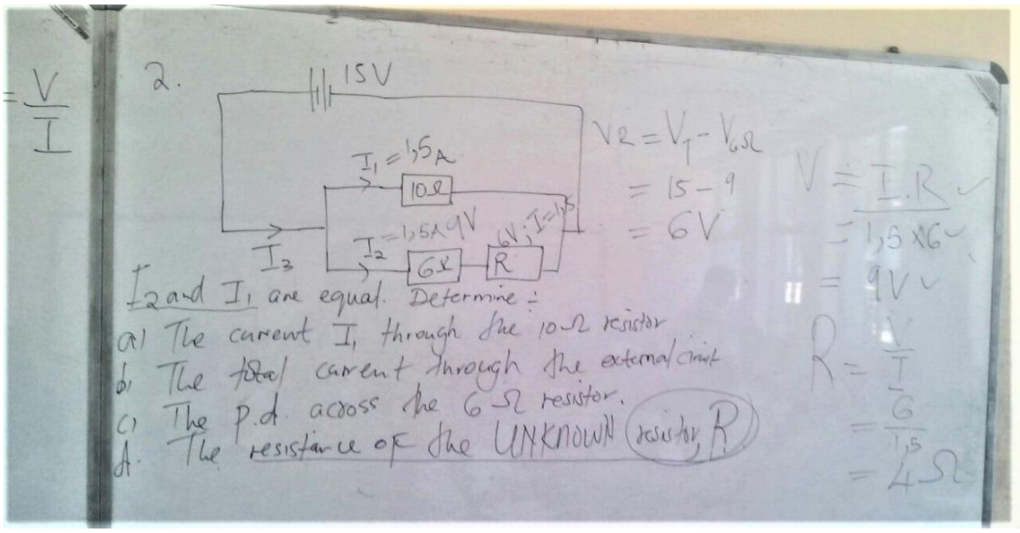


Figure 4-11: Example of Mbali's Grade 11 learners' work on electrical circuits

4.11.2.1 Analysis according to observation schedule

Assessing learners learning

Mbali assessed learners' previous knowledge on the Grade 10 concept of static electricity and later related learners' previous knowledge to the present lesson content on current electricity. She asked questions on the different types of electricity and the meaning of static electricity. Mbali used these questions as a means of introducing learners to a new lesson. During the practical demonstration, Mbali stopped the learners after each connection to ask them questions. It seems this was her own way of assessing learners' understanding of the lesson. Another instance where the teacher assessed learners understanding of the lesson was when she asked the learners to state Ohm's law and explain the relationship between V and R. Mbali also asked learners to attempt specific class activities from their textbook.

Instructional delivery

Mbali's lesson presentation was in accordance with the Lesson Study team's planned objectives. She presented an overview of the lesson and clarified learners' difficulties using a tabular representation of current and voltage across a series and parallel resistor. Mbali also demonstrated her knowledge of various teaching strategies by using inquiry-orientated practices to disseminate the lesson content. These skills will be elaborated upon when discussing her classroom interaction skills. Mbali related the lesson content to learners by emphasising important points that learners must know to enable them to solve questions in the lesson. Although Mbali did not use examples from real-life experience to enhance her teaching, she used relevant activities to clarify key concepts while teaching this lesson. She also used appropriate vocabularies in explaining important concepts. This was observed when she defined unfamiliar terms and clarified learners' minor difficulties through her explanations. Mbali has improved in her classroom practice and management skills as compared to her first and second lesson delivery. This was observed when she gave specific instructions asking the learners to control their noise and always indicate by raising their hand whenever they want to answer any question. It seems Mbali was determined to discipline any negative behaviour in her class during this lesson. The learners respected their teacher and maintained silence throughout the lesson.

Classroom interaction

Mbali involved the learners in a group activity which was practically orientated. This gave Mbali the opportunity to engage the learners in a whole class discussion since learners were required to explain what happened to the brightness of bulbs in both series and parallel circuit connections. Mbali demonstrated her knowledge of various teaching skills which included discovery learning, interactive demonstration, learners' participation and problem-based learning. This helped her to disseminate relevant knowledge to the learners and gave her the opportunity to relate well with the learners. Mbali used verbal questions to enhance the teaching process as learners in her class gave prompt responses to questions asked. Mbali created a good classroom environment that motivated learners' interest in the lesson by addressing learners' negative behaviour and reinforcing positive behaviours through several activities. This helped her to effectively manage learners' noise as opposed to what was observed in her first and second lesson. Mbali provided practical activities that supported learners' learning and understanding of the lesson. Mbali encouraged teacher-learner interaction in her lesson by calling out learners to explain and solve questions on the board.

Teacher's knowledge

Mbali demonstrated poor conceptual understanding of cause and effect when she explained Ohm's law. She attempted to explain the content on the difference between electromotive force and the potential difference across a circuit, but her explanation was not conceptually correct. Mbali's explanation during the lesson revealed that she had foundational knowledge of the subject. Though her teaching methodology was adequate, it lacked conceptual focus. Furthermore, her content presentation revealed gaps in her understanding. Her lesson delivery was seen to be well presented and accomplished because she taught the concepts of electric circuits using practical demonstration alongside her textbook and prepared notes. She also demonstrated her practical knowledge of the topic as she asked questions during the group practical demonstration to determine if the learners knew what they were doing. It seems that Mbali was committed to her learners' learning and enthusiastic about this lesson because she continuously checked learners' ability to understand the lesson by asking questions related to the concept she had taught. More so it seems Mbali was concerned about learners' ability to solve problems since she re-explained the addition of resistors in series and parallel more than twice, but not address conceptual understanding. However, she did not talk about the concept of effective resistance. At the end of the class-activity the teacher ensured that learners were given corrective feedback on the class activities attempted.

4.12 Lesson Study pair A's final reflection and reflective writing

The final phase of the Lesson Study cycle was a reflection section of teachers' experiences and challenges during their participation in this study. Teachers were unable to reflect together as a group since they were preparing for the Grade 12 learners' preliminary examinations. They did not keep a reflective journal as requested at the beginning of the study. However, teachers expressed their personal experiences and challenges during the Lesson Study process through informal discussions and reflective writings. The reflective writing was combined with teachers' responses to interviews for triangulation purposes. Teachers' reflection and reflective writings are discussed below.

4.12.1 Lenox's reflective writing

During an informal conversation with Lenox, he reflected on how the joint lesson planning phase and focus on learners' anticipated response became a different experience for him. He also reflected on time as a challenging factor that will not allow him to continuously engage in joint lesson preparation. Prior to participation in this study, Lenox had initially indicated that collaborating with other teachers is sometimes demoralising and a waste of time. He did not believe in discussing his classroom challenges with his colleagues since they had different learners. Lenox always expected learners to come to him and ask questions whenever he gave them class exercises. However, in his reflective writing he indicated a different view as shown in Figure 4.12.

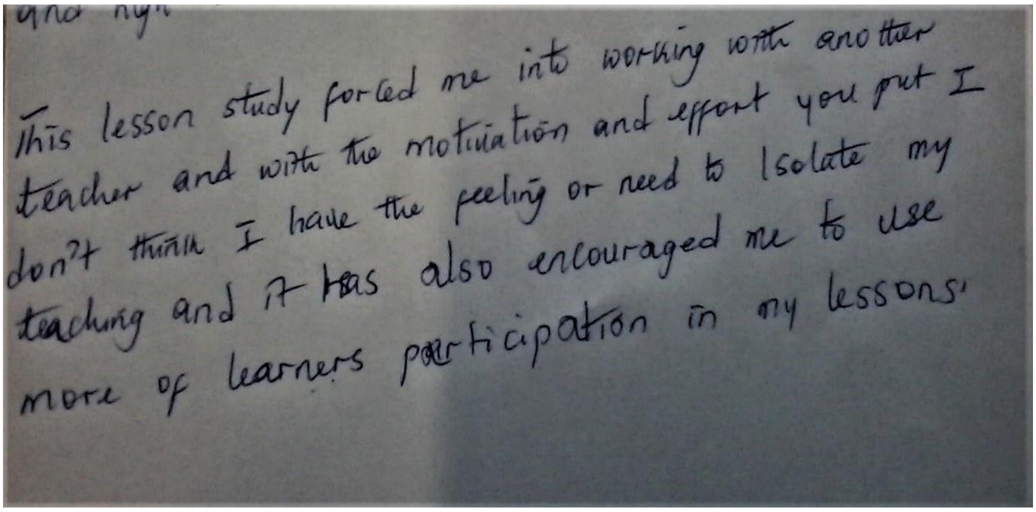

This lesson study forced me into working with another
teacher and with the motivation and effort you put I
don't think I have the feeling or need to Isolate my
teaching and it has also encouraged me to use
more of learners participation in my lessons.

Figure 4-12: Sample of Lenox's reflective writing

Lenox's reflective writing indicated that collaborating with his colleague has helped him to gain more confidence teaching a specific topic under electricity and magnetism. He also does not feel secluded when planning his lessons again. Participating in this Lesson Study has increased Lenox's knowledge on the use of learners' participation through calling them to answer questions on the board when teaching. Lenox reflective writing was linked to the theme of teacher's knowledge and collaboration.

4.12.2 Mbali's reflective writing

During an informal discussion with Mbali, she reflected on how participating in this study increased her confidence while teaching difficult concepts in electromagnetism. Earlier in the initial interview, Mbali mentioned that she used learners' performance and responses to questions whenever she marked as a way of assessing learners' understanding of a topic. It seems she found it difficult to give learners feedback on the activities since she did not mark learners work as often as she would have liked.

However, participating in this study improved Mbali's awareness on the importance of providing corrective feedback to learners. She also reflected on how Lesson Study improved her knowledge on other ways of assessing learners understanding of specific topics. Mbali's reflective writing is categorised under the theme teacher's attitudes, beliefs and impact on practice. A copy of Mbali's reflective writing is shown in Figure 4.13.

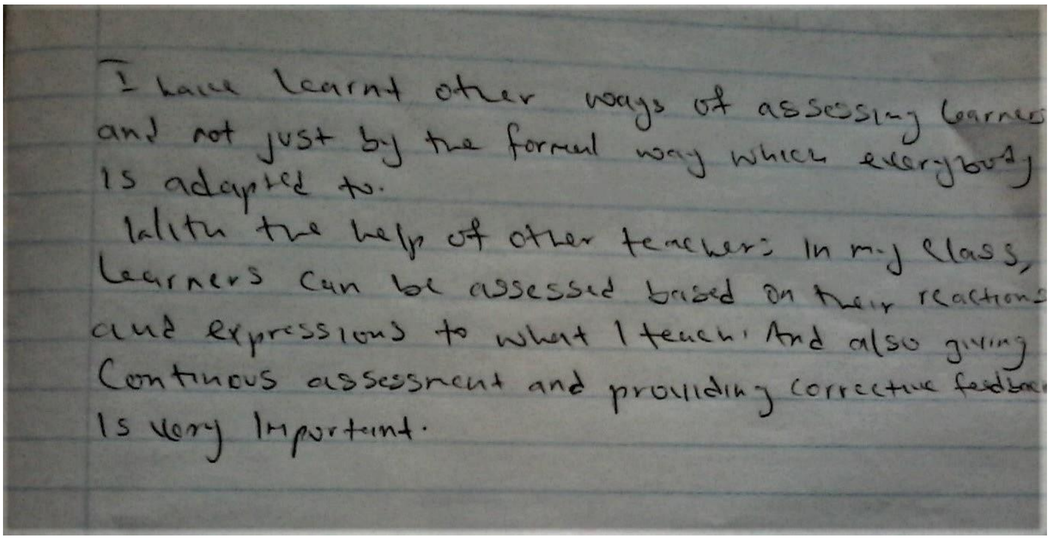

I have learnt other ways of assessing learners and not just by the formal way which everybody is adapted to.
With the help of other teachers in my class, learners can be assessed based on their reactions and expressions to what I teach. And also giving Continous assessment and providing corrective feedback is very important.

Figure 4-13: Sample of Mbali's reflective writing

4.13 Presentation and analysis of final interview

The final interview was conducted to explore participants understanding of using Lesson Study as a professional development model in teaching concepts related to electricity and magnetism. The data is presented based on the emergent codes and categories generated from the final interview which were later grouped according to pre-determined themes addressing the research questions. An overview of the codes, sub-themes and corresponding themes created during the final interview is presented in Table 4.6.

Table 4-6: Overview of codes, sub-themes, and themes created during the final interview with Lesson Study pair A

Codes	Categories/sub-themes	Themes
Good training but difficult Aids classroom management	Description of Lesson Study	Lesson Study experience
Collaborating Goal setting Requires a lot of time Involves a lot of thinking	Challenges of Lesson Study	

Classroom management and discipline Focus on learners learning Judgement of learners' assessment method Classroom teaching observation Collaborating with colleagues Reflecting on observed teaching practice Develop more teaching strategies Focus on learners' observation Understanding learners thinking	Advantages of Lesson Study	
Improved teacher's mathematical knowledge Improved specific content knowledge Improved teachers understanding Knowledge of learners' problem	Improved subject content knowledge	Teachers' knowledge
Use of classroom discussion method of grouping learners teaching methodology Development of other teaching strategies Improved knowledge of lesson plan writing Ability to use several teaching methods Knowledge of using more resources (text)	Improved pedagogical knowledge	
Managing instruction together Focus on learners' observation Anticipating learners' response	Teacher learning	Teachers' collaboration
Build working relationship	Teacher community	
Reducing isolation Increase teacher's confidence Taking risk together Increase teacher's competency	Teacher character	
Anticipating learners' response to planning learners' participation Increased teacher's awareness of learners learning instruction management	Learners' learning	Teachers' attitudes, and beliefs
Increased teacher's confidence teaching the topic Changed teacher's thinking about teaching approach Increased teacher's awareness of learners learning Changed teacher's belief about learners.	Teachers' character	
Time factor Low number of physical science teachers Need for specialised teachers	Resources	Contextual factors and challenges
Curriculum overload Teacher's workload Class size Teaching other subjects	Workload	
Fear of being criticised by colleagues;	Emotions	
Writing lesson plan Joint lesson preparation	Methods involved	
Power relationship School managers	Leadership	
Different classroom situation	Learning Environment	

4.13.1 Lenox's final interview

Lenox was interviewed on the same day he had his final reflection since he was not going to be free till the term closes. The interview was conducted in the physical science laboratory. The venue was not suitable for the interview due to noise from the photocopying activities going on in the laboratory. During the interview, Lenox effectively conveyed his feelings through his responses as revealed below.

4.13.1.1 Lesson Study experience

Lenox seems to have gained an understanding of how Lesson Study can be used to improve his classroom practice. He also believes that Lesson Study can only be effective when teaching specific concepts. Lenox's Lesson Study experience is illustrated in the conversation below.

> **Researcher:** *How would you describe Lesson Study?*
>
> ***Interviewee:*** *Lesson Study.................... what can I say? Hmmmmm ...it is a good training because I think it helped me in managing my learners and also improved discipline in the areas where I tend to involve my learners in more activities but I think that also depends on the nature of the topic one is teaching. What more? It helped me in assessing how my learners think. And it's a good way of allowing other teachers to see what goes on in my class.*

Lenox's response implies that Lesson Study can be used to improve classroom management and discipline among learners. This was also observed during his second lesson delivery when he sent a learner who was busy drawing on papers during his lesson out to stand in front of the whole class. During Lenox's explanation of his experience while participating in Lesson Study, he indicated that he noticed a particular learner whose thinking skills changed over the entire lesson. This increased his knowledge about how the learner thinks and responds to questions in the class. Lenox indicated that Lesson Study process should be used in a learning environment with a small number of learners. He said: "Lesson Study practice is a good method for small classes and not a big class like my own". During the interview, Lenox revealed the most interesting aspect of his Lesson Study experience as the opportunity given to him to anticipate his learners' response and make a quick judgment on what he thinks works best for his learners. It seems that Lenox enjoyed the opportunity given to him to focus on how his learners learn. However, It is not clear whether Lenox would have been able to experience the opportunity mentioned if he was planning his lesson alone. Elaborating on his challenges while participating in the study, he mentioned time as a challenging factor due to his job responsibilities. He also mentioned the goal setting of Lesson Study process as a challenging task that requires a lot of time.

4.13.1.2 Teachers' collaboration

Before participating in this Lesson Study intervention, Lenox emphasised the inadequate time, the small number of physical sciences teachers in a single school and job responsibility as challenges that do not allow teachers to get involved in collaborative activities. When expressing his views on the challenging aspect of Lesson Study, he mentioned sitting together as a big challenge. It seems that Lenox's explanation of sitting together means collaboration which he viewed as a waste of time as indicated in his Lesson Study challenges (see Appendix 13A). However, the researcher probed for clarification on Lenox's interpretation of waste of time. He said:

> ***Interviewee:*** *I will be serious with you. The system in place at the department and even in this school is a bureaucracy because learners are just admitted into the system for the sake of increasing the incentives and salary given to the school manager. The promotion criteria are not.......... So, the manager is not interested in your wellbeing all she wants is the result. They don't care about your challenges or what you face in the class and the learners are just too much. Imagine I have 245 learners in Grade 12 and 340 learners in Grade 11. How do you expect me to be productive, marking all their homework and class activity? So, you that time is not visible in this unless the department or principal gives time and employs more teacher to help.*

It seems Lenox's perception of collaborating with other teachers as a waste of time is influenced by his job responsibility, people in authority and promotion criteria. These are contextual factors and challenges that do not allow teachers to be effective in their classroom practice.

4.13.1.3 Teachers' knowledge

During the interview, the following question was asked:

> ***Researcher****: Considering the collaboration aspect of this Lesson Study process, how has it affected your professional knowledge and classroom practice?*
>
> ***Interviewee:*** *You see... I think it is all the same thing. This opportunity has helped me to use my classroom experience to increase my colleagues' confidence. It has also improved my teaching skills now that I have learned a new approach to teaching some concepts. And eeem… you know collaborating as teachers in the same school gave me the opportunity as well to manage instructions together.*

Though Lenox indicated that participation in Lesson Study has improved his own content knowledge, instructional practice, classroom management and pedagogical skills, he did not elaborate on how these skills were improved. He also remarked on how the collaborative practice of Lesson Study helped in building a collegial atmosphere as well as improving the professional attitude of his colleague. From the researcher's observation, it seemed that the collaboration phase of Lesson Study improved Lenox's confidence in teaching electromagnetism as opposed to what was mentioned during the initial interview (Section 4.5.1.1). This was observed during the classroom teaching where Lenox gave definite explanations on difficult concepts discussed at the planning meeting.

4.13.1.4 Teacher's attitudes and beliefs

Lenox believes that his participation in Lesson Study has improved his knowledge of physics to some extent. He indicated that his knowledge of electromagnetism is improving and his mathematics knowledge with respect to the required concepts needed in physics is also gradually improving. He also mentioned how the continuous practice of Lesson Study with learned colleagues could change his understanding of some physics concept for good. During the initial interview, he did not admit that he was struggling but during the planning he sought clarification on difficult concepts. During further clarification on Lenox's perception of the impact of Lesson Study on his professional knowledge and classroom practice, he responded:

Interviewee: *Heey ....sesi...frankly speaking, you know one can be teaching for many years and still don't have confident teaching some topics probably because you don't have interest in those topics but now think I have a feeling that I am beginning to build my own self-confidence in some aspects of this physics concept you are trying to research on and I will say that this Lesson Study training has positively affected my method to learning some physics concept by allowing me to visualise physical sciences in a more practical way than I use to. One thing that I have also realised is that there are different ways of thinking about a solution. So how I think about a solution is not necessarily how my learners will look at it. So now I try using more than one method of coming up with the correct answer which has given me more confidence to not always rely on the curriculum alone but use varieties of text to widen my knowledge of the best possible approach to use. This aspect of planning where you anticipate learners' responses to questions asked in the class has helped me to be in tune with what the learners are likely to respond to and not respond to. And you know ....eeeem this provides more information to the teacher when planning and teaching a lesson.*

It seems that Lenox's participation in Lesson Study has a direct effect on his professional knowledge in terms of improving his specific content knowledge and mathematics knowledge. It has also assisted him in increasing his professional character thereby creating an opportunity for him to develop more effective teaching strategies. Based on Lenox's response, it is clear that Lenox concluded that the Lesson Study framework can help teachers inquire about how to improve classroom practices through reflection.

4.13.1.5 Contextual factors and challenges

Lenox believes that the use of Lesson Study as a school-based professional development programme might not work unless extensive provision and resources are made available by the necessary authorities.

Researcher: *Are there any factors that might possibly affect your continuous use or practice of Lesson Study as a teacher?*

Interviewee: *Obviously.... time factor because the curriculum is loaded and we have few physical sciences teachers in school so it's difficult telling me to sit and plan a lesson with other teachers. Besides lesson planning is quite impossible and can never work because we have different school or classroom situations and different learners. Remember these association people did not even encourage us as teachers to use the lesson plan. Another reason why it will not work is that the school manager always wants you in class and the moment they see teachers gathering together they believe you are not doing your job. So, if you try to explain to them that you are doing things like this, they see you as a threat trying to dictate or take over their position from them and suggesting programmes like this to the area office without the manager's awareness is like looking for more trouble where there is none. You know what I mean so don't let me go into details. Then I feel this thing of not having specialised teachers might be a problem.*

Lenox's response reveals that teachers are faced with several challenges that hinder them from finding time to use Lesson Study as a collaborative professional model. He also identified classroom diversity as a contextual factor that will hinder teachers' collaborative lesson planning prescribed in Lesson Study. He believes that the misuse of power and authority by school managers and teacher unions could be a barrier to teacher's continuous practice of Lesson Study. This implies that Lesson Study should be introduced to schools' top down and not bottom up. Moreover, creating a profound working relationship with teachers and their peers, teachers and their learners, and educational authorities can sustain the use of Lesson Study as a school-based professional development training for physical sciences teachers.

4.13.2 Mbali's final interview

The final interview with Mbali was conducted in the physical science laboratory. She suggested that the interview is conducted between 12:00 and 13:00, which was her free period.

4.13.2.1 Lesson Study experience

Prior to the Lesson Study intervention, Mbali indicated that she has not participated in any form of practical professional development since she started teaching physical sciences. After participating in this study, Mbali described Lesson Study as good training with a difficult and complicated process. The researcher probed for clarification on Mbali's definition of difficult and complicated.

> ***Researcher:*** *Why did you say it's difficult or complicated?*
>
> ***Interviewee:*** *Time wena, it requires a lot of time if we really want it to work and that is not possible because I have too much to do with Grade 11 and 12 learners. I only spared you time because you are a student**.** More so, the planning aspect of it is just not visible as well except the department anchors it and gives us time during school hours to practice it. Hmmmmm it involves too many steps and requires a lot of thinking.*

Mbali indicated that the Lesson Study process is time-consuming. In her explanation, she indicated that the challenging aspect of the Lesson Study process is sitting together since teachers don't have time to sit and plan or carry out all the phases involved in the Lesson Study process. However, it seems Mbali's concern about contextual factors like job responsibilities, family commitment and different phases involved in the model made her describe Lesson Study as a difficult training. She elaborated her description of Lesson Study based on her Lesson Study experience and compared it to previous professional development programmes attended while teaching mathematical literacy.

4.13.2.2 Teacher's collaboration

Mbali had previously identified collaboration in terms of sitting together as the most challenging aspect of her Lesson Study experience. However, it seems that Mbali valued the collaborative phase of the Lesson Study process. This was confirmed when she said:

> *"I enjoyed collaborating with my colleague and I was able to visualise my learners' response to the intended activity. More so, the collaboration activity gave me the opportunity to figure out what my colleague knows about the topic"*

She mentioned how the brainstorming session of the Lesson Study meeting helped improved her knowledge of the mathematics method required to solve some physics concepts especially those involving parallel combination of circuits. Mbali also emphasised the importance of collaboration among teachers and learners as an important aspect of improving one's practice. This was observed when she mentioned that she had gained a lot from her colleagues' experience and now she believed that if she is working with somebody or a group of people who share the same classroom problem with her, they were likely to see where their learners were coming from in terms of their academics and they can plan together on where the learners needed to be in the future. This could imply that teachers sometimes don't have all the answers to what they teach or questions asked by their learners in the class, but working with somebody outside a teacher's class can make the job easier due to the support he/she will be getting from others. In conclusion, the collaborative phase of the Lesson Study process gave Mbali and Lenox the opportunity to collectively plan their lessons towards the academic growth of their learners.

4.13.2.3 Teacher's knowledge

Mbali's reflection on the most engaging phase of her Lesson Study experience revealed how the collaborative practice of Lesson Study influenced her knowledge level and teaching practice. This was noted during the conversation below .

> ***Researcher:*** *What aspect of these Lesson Study process is more interesting to you?*
>
> ***Interviewee:*** *The interesting aspect of this is the group discussion because I was able to understand how to explain the direction of magnetic field on the board using my hand and problem-solving aspect on magnetic flux which my partner fully explained to my understanding because I was finding it a bit confusing. I also enjoyed the aspect of reflecting on how the learners responded after leaving the class. You know [Smiling], I just teach based on the curriculum and what they want us to teach but one thing I think I saw that was interesting in this your Lesson Study especially when we were planning the lesson is the ability to think about what I want my learners to know while teaching the lesson and I was able to see the importance of that thinking because a lot of critical issues was raised and I was able to know why the topic should be taught and*

how to teach it to the learners. Another interesting thing that I can say I benefited from was the ability to develop new instructional approaches based on the different learners' background especially with those slow learners.

During the initial interview, Mbali indicated that she was struggling with electromagnetism but she did not specify the concepts that appeared difficult to her as a teacher. Her response indicated that the collaboration phase of planning the lesson together helped her to better understand specific concepts under electromagnetism which initially appeared difficult to her.

4.13.2.4 Teacher's attitudes and beliefs

During Mbali's reflection on how the collaborative phase of Lesson Study influenced her knowledge and practice. She explained how her attitude towards her colleague has improved, when she mentioned that the collaboration process has really helped her to build a working and friendly relationship with her colleague; which tends to have a way of helping her to gradually reduce her habit of planning and teaching in isolation. She also reflected on how Lesson Study has improved her personal attitude and teaching practice.

Researcher: *What is your perception of the impact of Lesson Study on your classroom practice and professional knowledge?*

Interviewee: *Ha...ha...ha... This your questions are becoming too much... leboga .... (Thank you). it has also helped me to a greater extent in bringing down this wall I have built around me when teaching this particular electromagnetism in which I don't answer some questions that learners tend to ask. I just teach and leave. Then you know I use to teach math literacy but there are some real mathematical concepts involved in physics which I think am gradually taking my fear away from it with the help of this collaboration process involved in Lesson Study. Then I guess I need to conclude with the fact that now I have the confidence in teaching this topic electromagnetism to my learners. I can now explain all the detail concept of how to determine the direction of fields which I do struggle with before.*

Mbali had earlier indicated that she struggled with a specific topic under electricity and magnetism, this made her lack confidence in teaching the topic. However, participating in Lesson Study has improved her teaching confidence due to her improved knowledge. Her response also reveals that she has learned to always integrate her learners' questions to her classroom teaching on electromagnetism, which in turn improved her teaching attitude. During the conversation, Mbali also explained how Lesson Study has influenced her classroom practice, indicating that teachers in the same school can also use this kind of study to identify learners' difficulties that are applicable in their own school.

> ***Interviewee:*** *My classroom practice, hmmmmm…… a little and that is calling learners to solve questions on the board. Learners' difficulties I will say Lesson Study has helped me learn how to identify concepts that are problematic to learners based on their classroom discussions. And now I know that learners have to be properly grouped before they can make meaningful discussion amongst themselves. Now I know that I have to pick the average learners and group them with the slow ones so they can motivate one another as compared to before when I just ask them to group their selves. Hmmmmm another thing I think has changed in my practice is starting my teaching with questions and I believe calling them out to solve questions was able to build their courage. Then you know at the second class, I was able to manage my teaching by giving a detailed explanation as you explained and I think it was efficient for me because the learners' reaction to the answers showed they understood.*

Her response indicates that participating in Lesson Study improved her pedagogical skills and practice. She engaged her learners in the teaching process through a learner participation approach rather than just teaching and leaving as mentioned earlier. This was also observed during her second lesson delivery when she called out learners to practically demonstrate and explain the concept of "in page" and "out of page" using a paper and a pen. It seems Mbali was concerned about how to support her learners' learning. Participating in Lesson Study improved her knowledge of how learners' learning can be supported through the use of interactive teaching strategies that encourages learners to pair, think and share information amongst themselves. She also used collaborative activities in form of classroom discussion to understand learners perceived difficulties in the topics she was teaching and to assess her learners' problem-solving skills. It seems that Mbali's pedagogical practice was effective since the learners correctly explained the concept she taught them and they were able to solve the problems.

4.13.2.5 Contextual factors and challenges

During Mbali's reflection on her Lesson Study experience, she mentioned unavailability of time as a challenging problem in Lesson Study. Her explanation of time involved her workload and job responsibility. However, she elaborated on other possible factors that might affect teachers continuous practice and effective participation in Lesson Study if introduced to schools.

> ***Researcher:*** *So what are the other factors that will affect your continuous practice of Lesson Study?*
>
> ***Interviewee:*** *Our managers will not make this work too because they believe so much in us going to class to teach so giving us few minutes during the week as teachers to collaborate departmentally is sometimes a problem you know these people had their education long time ago and they still believe in their one ways of doing things forgetting that we now live in a different educational era where learning is done differently. Another thing I can say will not make me use this approach is I have too much of workload. This is a Government school where we have a lot of physical science learners in the technical stream and science and commercial stream. The workload in this school is just too much and like I said earlier I also teach other subjects, so I need to plan for those subjects too. Also, I will say the absence of a subject adviser will not make this work too. I believe if we have a subject adviser, he/she will probably be informed or be aware of this kind of training and am sure she will design a programme to enable us to use this which am sure will be well implemented in schools if they receive direction from the department. Another reason why I said this study cannot work is that some of our colleagues will over criticise your approach and turn you down, this can demoralise you as a teacher if you are not confident of yourself. Then using several teaching methods in a class where the learning difficulty of learners varies may not allow this method to work effectively.*

Mbali's views on contextual factors are similar to that of her reflection on challenging aspects of Lesson Study. Mbali blamed the possibility of not practising Lesson Study in schools on lack of support from school leaders and absence of professional experts at the district level. She believes that school managers are more focused on learning activities than creating professional development avenues for teachers in their schools. Mbali has not attended any form of training since her three years of teaching physical sciences due to the absence of a subject adviser. She assumes that the role of the subject adviser is to pass information to schools and give teachers the opportunity to attend practical training like Lesson Study within the district. Her response also reveals that she sees the streams of learners she has to teach in a week and the additional subject she is teaching as a challenging and contextual factor to practising Lesson Study. It seems Mbali is accustomed to making her classroom practice personal, but it is not clear whether she has a problem opening her class to other teachers. This was observed when she mentioned how her emotions can hinder the practice of Lesson Study, indicating that she is afraid of the negative comments that other teachers could make. She believes that such negative comments could hurt her feelings or make her feel inferior to other teachers. More so, Mbali indicated that teachers have complained to the district officials about the possibility of creating time and opportunities for teachers to meet departmentally once a week but there was no positive response to it. Based on Mbali's response, the researcher recommends that school leaders such as principals/managers, district, and provincial officials should be well placed to support the implementation and sustenance of Lesson Study in schools, by creating time for teachers to engage in professional development programmes either departmentally or as a whole within their schools. It is also suggested that teachers need to be involved in professional development programmes that will help them improve their professional attitude with other teachers without taking offense.

4.14 **Analysis of participants documents**

According to Denzin (1970, p.291) document analysis could be combined with other qualitative methods for triangulation purposes. Document analysis was used in this study to understand how teachers originally planned and prepared for their lessons. It was also used to check data obtained from interviews and classroom observations. The documents viewed in this study are the teacher's original lesson plans and their reflective writing. Findings from teachers' reflective writing have been discussed in Section 4.12. However, findings from each teacher's original lesson plan are discussed.

4.14.1 Teacher's original lesson plan before the research

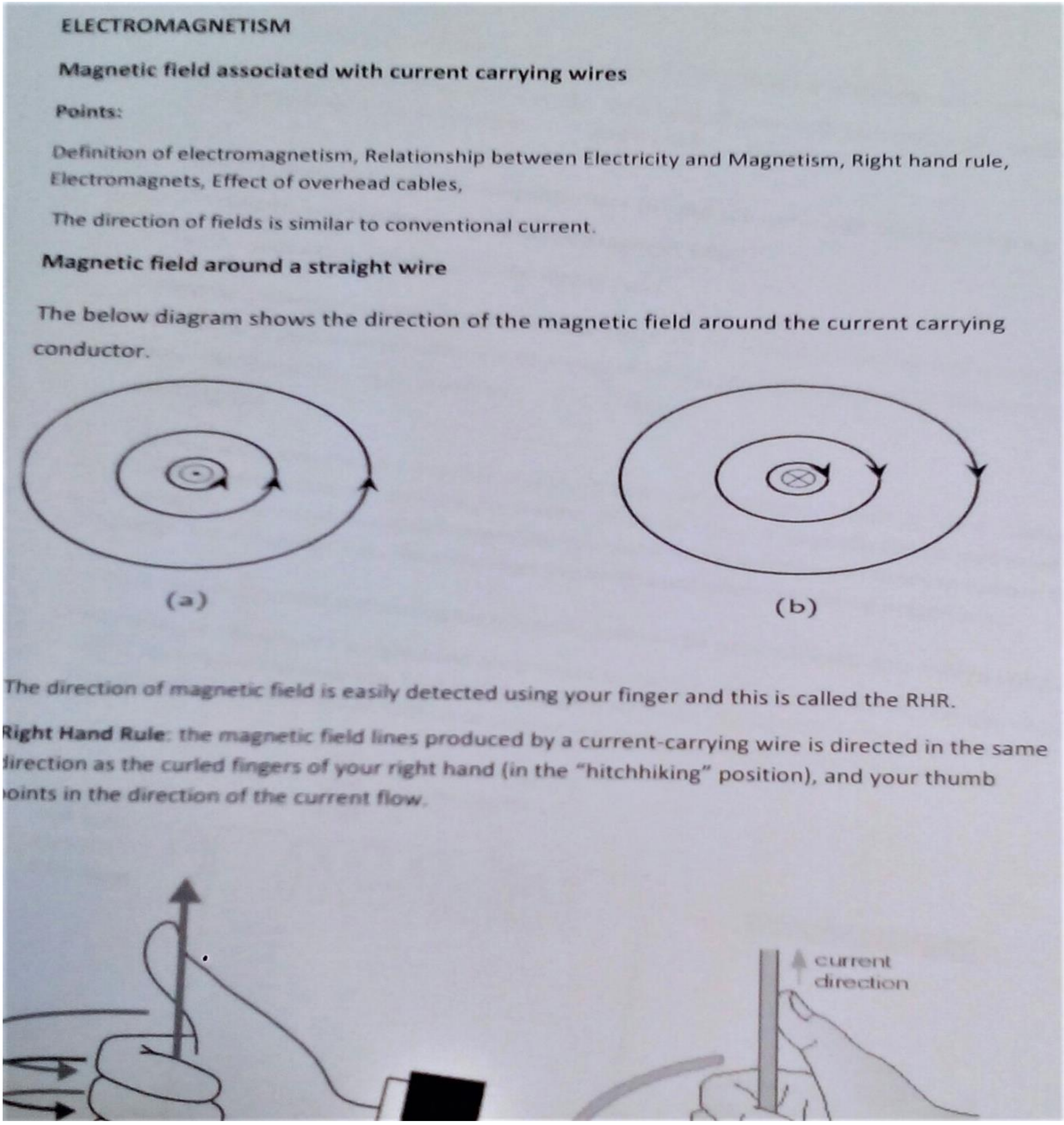
The findings from teacher's original lesson plans are discussed based on the guidelines provided in Appendix 12. The elements to be discussed in the analysis of teachers' lesson plans include the outline of goals and objectives for the lesson, reflection on learners' previous knowledge, teacher's inquiry methods, class activity based on practical demonstration, evidence of learners' class activities and feedback.

4.14.1.1 Lenox

Lenox is an experienced teacher with a negative attitude towards writing a lesson plan. He believes that writing a lesson plan is time-consuming and stressful. During a casual conversation, Lenox was requested to present his original lesson plan. He responded by saying,

> ***Lenox:*** *Now I don't know what you mean by lesson plan because the association is not in agreement with it. I will say lesson plan is for the department and not for me. Seriously I don't write a lesson plan. My plan is on my xixingiwa…..****("****laptop") as you can see. All I do is teach according to the curriculum and ensure that learners are exposed to the necessary practical outlined in the curriculum.*

Lenox's response indicates that he reads and prepares for his lessons before going to teach the learners but he does not write a standard lesson plan. The document provided by Lenox as his lesson plan is a section downloaded from a textbook or other study material, printed from his laptop. It only reflected key points that learners are expected to know and a summary of points to be discussed in the class, as shown in Figure 4.14. There was no indication of teaching methodology to be used, no outline of goals, objectives or instructional materials; no indication of learners' assessment or planned learners class activities. The presented lesson plan did not provide a description of how the lesson fitted into a larger unit of the curriculum, reflection on possible learners' difficulties to be addressed, evidence of teacher's feedback to learners and how the teacher planned to conclude his lesson.



ELECTROMAGNETISM

Magnetic field associated with current carrying wires

Points:

Definition of electromagnetism, Relationship between Electricity and Magnetism, Right hand rule, Electromagnets, Effect of overhead cables,

The direction of fields is similar to conventional current.

Magnetic field around a straight wire

The below diagram shows the direction of the magnetic field around the current carrying conductor.

(a)

(b)

The direction of magnetic field is easily detected using your finger and this is called the RHR.

Right Hand Rule: the magnetic field lines produced by a current-carrying wire is directed in the same direction as the curled fingers of your right hand (in the "hitchhiking" position), and your thumb points in the direction of the current flow.

current direction

Figure 4-14: Sample page of Lenox's original lesson plan on Electromagnetism

4.14.1.2 Mbali

An investigation into Mbali's original lesson plan revealed that her lesson plan was not newly written. She has been using the same lesson plan since she started teaching physical sciences as a subject three years ago. The researcher, as an experienced physics teacher, understands that not all lesson plans are the same. The presented lesson plan was written in English and did not indicate the roles of the learners in terms of goals, objectives or class activities to be carried out. Some aspects of the lesson plan she presented were handwritten while other aspects of the lesson plan seemed to be attached photocopies of pages obtained from physical sciences textbooks. The hand-written parts of her lesson plan have the following sub-headings: date, topic, notes, practical, conclusion, homework, and correction; while the attached photocopied pages obtained from textbooks were classified under subheadings like examples and keywords. Her lesson plan missed out some necessary information that is required to be in every lesson plan like period, duration, resource material used, instructional material, learners' previous knowledge, teaching methods, procedures and learners' activity. More so, Mbali did not describe how her lessons fitted into a larger unit of the curriculum and the importance of each lesson to learners was not stated in her lesson plan. The teacher's original lesson plan did not indicate any form of activity that could be used in assessing learners' prior knowledge. neither did she outline the teaching methods to be used while teaching her lessons. The content of Mbali's lessons on topics to be taught was well explained and documented in the original lesson plan provided. Her lesson plan on electromagnetism illustrated a practical investigation on how to determine the direction of a magnetic field line using iron filings and a compass as shown in Figure 4.15.

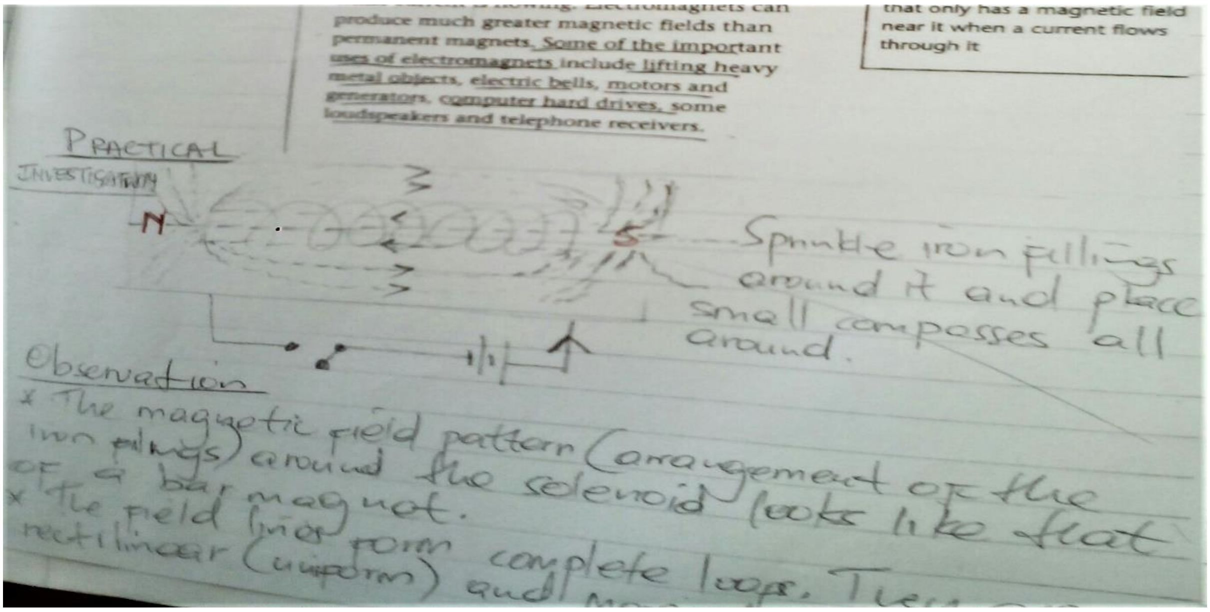


Figure 4-15: Sample page of Mbali's original lesson plan on electromagnetism

Her lesson plan on electric circuit involved typical class examples, learners' homework, and proposed corrections in terms of feedback to give to learners. There is every indication that her original lesson plan demonstrated her knowledge of subject matter and the curriculum. A sample of Mbali's planned learners' homework and feedback is provided in Figure 4.16.

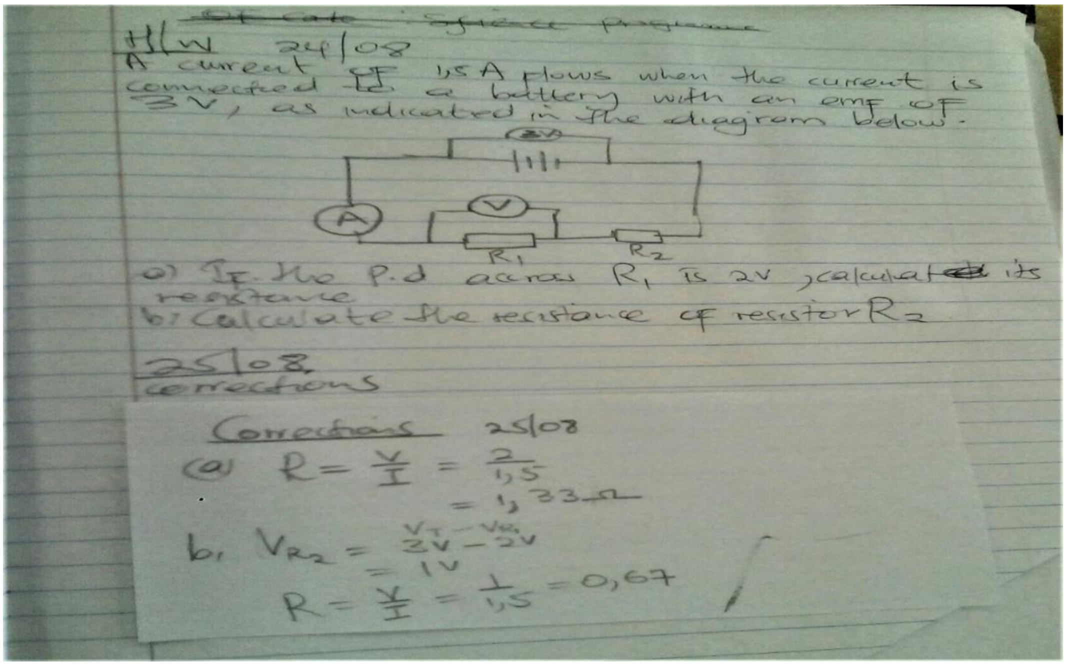


Figure 4-16: Examples of Mbali's planned learners' homework and feedback on electric circuit

A summary of the teaching methods found in the analysis of pair A's original lesson plan before participating in Lesson Study is presented in Table 4.7. However, the final lesson plans presented at the end of the Lesson Study intervention by pair A addressed the criteria outlined in Table 4.7 (see Appendix 15).

Table 4-7: Comparison of lesson study pair A's lesson plans

Criteria	**Initial lesson plan**		**Final pair plan**
	Lenox	**Mbali**	
Teacher's description of how the lesson fits into a larger curricular unit			**f**
Activities in teacher planning that assessed or stated learners' prior knowledge			**f**
Outline of inquiry methods to be used while teaching the lesson		i	**f**
Outline of teacher's expectation of what learners should know and be able to do at the end of lesson			**f**
Instructional materials teacher used in the class while teaching the lesson			**f**
Content/procedure standard	i	i	**f**

Teacher’s feedback to learners		i	**f**
Teacher’s wrap up/conclusion			**f**
Planned learners’ assessment		i	**f**
Notes for teachers to reflect on the lesson taught.			**f**

i = found in the initial lesson plan, f = found in final lesson plan

Table 4-7 shows the difference in teacher’s initial and final lesson plans. Analysis of pair A’s lesson plans reveals that the initial lesson plans were content-driven. However, subtle guidance provided by the researcher on learners’ possible responses as indicated in the lesson plan template used by the teachers, and reference to learners’ difficulties during the initial interview stimulated teachers’ awareness about learners’ learning. Comparison of teacher’s lesson plans suggested that the researcher’s questions on learners’ learning and difficulties provided an instructional shift in teachers’ lesson plans from teacher-centered to learner-focused teaching during this study.

4.15 **Conclusion**

In this chapter, the data collection process that took place in the rural school during the third academic term of 2016 is presented. The analysis of data obtained through interviews, Lesson Study meetings, classroom lesson observation and documents of two Grade 11 teachers as the Lesson Study pair for this research work was also discussed.

The data obtained during classroom observation were presented based on criteria in the observation schedule and data obtained from teacher’s original lesson plan was presented using criteria in the document analysis guide in Appendix 12. Data obtained during the interviews were presented based on the emergent codes and categories which were later grouped according to pre-determined themes in the research questions. These pre-determined themes were deductively created and they are teacher’s knowledge and collaboration, Lesson Study experience, teacher’s attitudes, beliefs and impact on practice, as well as contextual factors and challenges.

Data gathered and analysed from the Lesson Study pair at the rural school revealed the following:

- Lenox does not consider electromagnetism as a challenging topic for learners because learners are not assessed on that topic at the matric level. However, his participation in this research study changed his belief and understanding about learners' difficulties in electromagnetism since he was able to identify various challenges that learners encountered during the researcher's interaction with him and Mbali during one of the Lesson Study meetings.
- Mbali had earlier indicated that she is finding it difficult to teach some concepts in electromagnetism. However, collaborating with Lenox and the researcher increased her understanding of how to explain a difficult concept like the direction of the magnetic field on the board using her hand and clarified her method on how to solve problems on magnetic flux. This was observed in her class and also mentioned during her final interview.
- Participants initially use only lecture method approach in addressing learners' difficulties but participating in this research aroused their interest in engaging learners by calling them out to solve questions on the board. This is a positive impact on teachers' classroom practice.
- Both teachers didn't use to write lesson plans but participating in this study has improved their knowledge on how to write a good lesson plan and this helped them to become more aware of how their learners learn.
- Lenox and Mbali originally had a negative view about collaborating with one another since they mentioned that they had many responsibilities and did not have time to sit together for a long period. However, working together with a professional expert changed their perception about collaboration and created an opportunity for them to learn from one another, build a working relationship in terms of teacher community and increase their competency and confidence when teaching specific concepts (electromagnetism) related to electricity and magnetism.
- Both teachers have a perception that science is difficult since they indicated that they needed to do a lot of reading and thinking before going to class. This could mean that Lenox and Mbali were not adequately prepared to teach physics content and it was possible that this negative perception could be responsible for the gaps identified in their lesson planning, their poor conceptual teaching knowledge and inappropriate use of vocabulary words. However,

Lenox mentioned that participating in this practical intervention has to some extent improved his knowledge on the electromagnetism and mathematics knowledge required for teaching some physics concepts. He believes that continuous practise of Lesson Study with learned colleagues could improve his understanding of some physics concepts.

- Participants experienced an improvement in their application of mathematics knowledge to problem-solving and in their application knowledge of several teaching strategies when teaching electromagnetism and electrical circuits;
- Participants' beliefs and attitude towards learners' difficulties in electromagnetism changed after participating in Lesson Study. For example, Lenox's perception on learners' difficulties as concepts examined at the matriculation exam changed after the planning and discussion session. It is believed that this change in perception may change their classroom practice for a long time.
- Participants revealed their understanding of the Lesson Study process when sharing their experiences. For instance, Mbali described the Lesson Study process in her interview "seriously it's a good training but it's difficult or I say the process is complicated." (Mbali, Interview, September 23, 2016).

This was confirmed in Lenox's statement:

> *Lesson Study.................... what can I say? Hmmmmm ...it is a good training actually I think it helped me in managing my learners and also improved discipline in the areas where I tend to involve learners in more activities but I think that also depends on the nature of the topic one is teaching. What more? It helped me in assessing how my learners think. And it's a good way of allowing other teachers to see what goes on in my class. (Lenox, final Interview, September 22, 2016)*

This chapter gave a detailed account of the results obtained from the Lesson Study experience of two Grade 11 teachers from a rural school. The researcher feels that the challenges indicated by participants in this chapter can be addressed by seeking support from the necessary authority. However, participants' views on the benefits of this study signify the importance of implementing Lesson Study as a school-based professional development program. This would help physical sciences teachers to open their classrooms for observations and develop self-awareness on their classroom practices with the purpose of meeting their learners' academic needs. The next chapter presents findings obtained from the Grade 10 Lesson Study pair during the 2017 academic year.

5. CHAPTER 5: RESULTS FROM LESSON STUDY PAIR B

5.1 Introduction

In this chapter, results obtained from two different city schools as a case study that exclusively focused on Grade 10 physical sciences teachers' Lesson Study process are presented. The data analysis presented in this chapter is based on the interpretation of participants' views and behaviours about the use of Lesson Study in teaching. The biographic information of research participants and their school context are presented. Secondly there is a timeline of the data collection process. Thirdly, the findings from the initial interviews based on a priori themes generated from the study are presented. This is followed by the results of all Lesson Study activities. These include pair planning, individual classroom teaching and pair reflection. The chapter is concluded by the presentation of participants' final interviews and analysis of participants' documents

5.2 Biographic Information

5.2.1 Martha

Martha is a female teacher with a Bachelor of Science degree (BSc) in Human Genetics and a Postgraduate Certificate in Education (PGCE). She has been teaching physical sciences for seven years in Duncan high school. She also teaches Technical Sciences to Grade 10 learners and has a total workload of 32 teaching periods per week.

School context

Duncan high school is a public secondary school with a well-resourced science laboratory. The pass rate for physical sciences learners in this school in the 2016 matriculation exams was around 57%. The laboratory has a functioning projector but no computers. However, the physical science teacher uses her laptop with the projector to enhance learners' understanding of the subject. The laboratory has a bookshelf containing several physical sciences textbooks, science dictionaries and different folders containing several instructional materials. Learners in this school attend the physical sciences lessons in the laboratory.

5.2.2 Alex

Alex is a male teacher with a Bachelor of Education (B.Ed) degree in Further Education and Training (FET) Natural Sciences. He has been teaching physical sciences for five years in Roderick high school. He is teaching physical sciences to Grade 10 and 12 learners, and has a total workload of 36 teaching periods per week.

School context

Roderick high school is a public school with adequate resources and laboratory facilities. However, the laboratory equipment is not sufficient for individual learners participating in practical experiments. The pass rate for physical sciences learners in the 2016 matriculation examination was 50%. During physical sciences lessons, teachers and learners in this school go to the physical science laboratory for their lessons. The laboratory also has a projector which is used for supporting learners' understanding of specific topics.

Both schools are in the suburbs of a large city. The physical sciences teachers in both schools struggle with learners' performance across Grade 10 to 12. Teachers indicated that learners' performance in the subject is poor because of the 30% pass mark stipulated by the Department. Teachers believe that the promotion criteria are extremely low and do not support the knowledge and understanding of physical sciences. A summary of participants' biographical information is provided in Table 5.1.

Table 5-1: Biographical information of participants in Lesson Study pair B

Pseudonym	**Martha**	**Alex**
Gender	Female	Male
Qualifications	BSc (Human Genetics); PGCE	B.Ed (FET) Natural Sciences
Years of physical sciences teaching experience	7	5
Grades teaching	10PS, 12PS, 10 TS	10PS, 12PS
School type	Suburb in a city	Suburb in a city
Laboratory resources	Adequately resourced	Adequately resourced

PS – PHYSICAL SCIENCES, TS – TECHNICAL SCIENCES

5.3 Data collection

Details on the data collection process have been discussed in Section 3.5. A timeline of the data collection process for Lesson Study pair B is provided in Table 5.2.

Table 5-2: Timeline for the data collection process for Lesson Study pair B

Lesson topic	Pseudonyms	Date	Data gathering technique
N/A	Martha Alex	21/04/2017 24/04/2017	Initial interview
Magnetism	Alex, Martha	04/5/2017	First group planning of lesson 1
	Alex Martha	05/05/2017 09/05/2017	Classroom observation for lesson 1
	Alex, Martha	11/05/2017	First reflection on lesson 1; Second group planning of lesson 2
Electrostatics	Alex Martha	15/05/2017 16/5/2017	Classroom observation for lesson 2
	Alex, Martha	18/5/2017	Second reflections on lesson 2; Third group planning of lesson 3;
Electrical circuits: series, parallel and combined circuits	Alex Martha	19/5/2017 23/5/2017	Classroom observation for lesson 3
	Alex Martha	01/06/2017 05/06/2017	Final reflection on lesson 3 and final interview

5.4 Presentation and analysis of initial interview

The emergent codes presented in this section are different from the emergent codes presented during the analysis of Lesson Study pair A's initial interview. The response obtained from the interviews is presented according to the emergent codes which were later categorised under emergent themes and a priori themes created from research questions. The list of emergent codes, sub-themes, and themes created from data obtained during the Lesson Study pair B initial interview is presented in Table 5.3.

Table 5-3: List of codes, sub-themes, and themes created during the initial interview with Lesson Study pair B

Codes	Sub-themes	Themes
Teacher's certification Teacher's foundational knowledge Teacher's teaching experience across FET phase Teacher's perception of learners' difficulties; Teacher's own knowledge Teacher's difficulty Subject discipline at University level Difficulty in Grade 12 content Teaching experience	Content Knowledge	Teacher's Knowledge

Open communication Teacher’s expectation from learners Short test Class test Homework Individual attention to learners	General pedagogical knowledge	
Explanation, analogies Teacher’s teaching experience Use of pictures Teacher’s use of practical demonstrations Downloaded simulations Encourage learners to practise Use of simulations Download videos Internet resources Pick learners randomly for a question and answer during the teaching process Internet resources 21st-century learning approach	Teaching strategies and practice	
Learners have problem in electric circuits Learners don’t understand concepts in electromagnetism Learners negative attitude towards science Difficulties in drawing magnetic field lines Problem understanding magnetic flux Problem with series,and parallel circuit combination Maths problem Don’t know how to convert Teacher’s understanding of learners’ background Teachers flexibility in giving homework Communication with parent	Knowledge of Learners’ difficulties	
No workshop exposing teacher to first-hand methodologies in physics	Need to improve teachers’ workshop on physics methodologies.	Teachers’ collaboration
Communicating with the department without feedback No provision for training physical sciences teachers	Problem with collaboration	
Organised workshops by the department; Support from the school	Support from respective education authorities	
Teacher’s confidence about learners’ problem Teacher’s perception of learners’ difficulties Teacher’s awareness about her teaching challenges Endorsing learners work using stamp Provide correction on learners’ work	Teacher’s attitude	Teacher’s attitudes and beliefs
Teacher’s passion for the profession Teacher’s character Teacher’s confidence Love for the profession Teacher’s interest in teaching Teacher’s expectation from learners	Teacher’s belief	

Look at how my lesson went Teacher's intuition about learners' understanding	Reflection	
Teacher's confidence Teacher's belief	Teacher's character	
Re-explaining Motivating learners	Pedagogical skills	
Learners attitude to homework	Knowledge of learners	
Teacher's participation in professional development programs	Teacher's professional development needs	
Teacher's intuition about learners understanding Look at how my lesson went	Reflection	
Insufficient time to cover syllabus	Time factor	Contextual factors and challenges
Problem with school budget	Support from the school	
Repetition of information by facilitators from the department	Need to improve teacher's workshop	
Teacher's belief Teacher's perception Outcome from workshops	Teacher's character	

5.4.1 Martha's initial interview

The initial interview with Martha was conducted on the 21st of April 2017 in the conference room at Duncan high school between the hours of 14:20 and 15:10.

5.4.1.1 Teacher's collaboration prior to Lesson Study

Martha indicated that struggling with specific content as a teacher helps in identifying possible learners' challenges. However, Martha does not engage in collaborative activities that are extensively focused on teachers' challenges and discussions on teaching strategies. She believes in using technology "(google and internet resources)" to address her difficulty in specific content. The researcher probed for clarification in understanding her collaborative practice as a teacher.

> ***Researcher:*** *Since you use google, don't you discuss this difficult concept with other teachers in your school or outside your school?*
>
> ***Interviewee:*** *Yes, I do. For Grade 12 I sometimes discuss with my HOD and Grade 11, I discuss with the other teacher but for Grade 10 I have no one to discuss that with. So, my HOD helps a lot with the Grade 12 work. I quickly run to her to explain one or two things and that is it. But we have not really had that time to sit down for an effective collaboration that lasts long if you know what am trying to say. Everybody is busy with their own thing and our teaching*

periods are different so that free period where we all gather together has not really surfaced based on the timetable. From outside school, let's not delve into that.

Her response reveals that she occasionally sought clarification on teaching challenges through open conversation and peer consultation with senior teachers in her school. She indicated that such discussions provided immediate solutions to her classroom problems. It seems that Martha and other teachers in the science department are finding it difficult to create a common time for effective collaboration. She also mentioned an ineffective communication process between teachers and district officials as a one of the problems affecting her collaborative activities outside the school. This was observed when she said,

"Eeem we don't have a lot of professional development programmes in our district or maybe I say we hear of them very late because the communication from the district office to the school is somehow a problem."

Martha's response on time and ineffective communication will be discussed in detail as contextual factors affecting her collaborative practice.

5.4.1.2 Teacher's knowledge

Martha demonstrated her understanding of learners' difficulties when she mentioned that learners across Grade 10, 11 and 12 have a problem understanding the concept of the electric circuit due to their lack of mathematical operational knowledge. The researcher probed for clarification on other concepts that learners might be finding difficult.

Researcher: *Okay so is the difficulty only in electric circuits?*

Interviewee: *Well for Grade 10 I will say yes although some of them still struggle with details on how to draw magnetic fields….the percentage is very small so I don't think that is a problem. For Grade 11 there is this big problem when it comes to magnetic flux. It is a difficult concept for the learners.*

Martha believes that FET learners find it difficult to understand the concept of electric circuits because they have problems with using mathematics. She indicated that there are some topics under electricity and magnetism that appear difficult to learners at their different grade levels. During her explanation, she attributed some of the learners' difficulties to learners' lack of discipline, poor lesson attendance and their negative attitude towards the subject. This was observed when she said,

> *"They are naughty sometimes and they have this bad attitude towards science. More so, Grade 10 learners are expected to attend compulsory extra lessons every Tuesdays, unfortunately the lesson is not well attended.*"

Martha indicated that she is finding physics topics in the Grade 12 CAPS syllabus challenging because that was her first-time teaching Grade 12. It is possible that Martha is struggling with how to present concepts in the Grade 12 syllabus in a meaningful way to learners. This shows poor pedagogical content knowledge at this stage of her career. The next conversation described the teaching strategies used by Martha in helping learners overcome their difficulties.

> ***Researcher:*** *Okay so what method have you been using to address your learners' difficulties in electricity and magnetism?*
>
> ***Interviewee:*** *Maths is very much relevant to understanding physics and this is a big problem for my learners. However, for example in Grade 10 magnetism I try as much as possible to do practical experiment with them even if it's just a demonstration. For the electricity, what I have done is that I downloaded simulations and until last year we had a computer centre, unfortunately our computer centre is closed this year but am going to try and get something for my class this year. But the simulations have helped quite a lot because they can see what happens with the voltage and current when resistance is either connected in series or in parallel that type of thing. Eeem but otherwise practise makes perfect. Practise practise practise.*

Martha's response gives the impression that she is concerned about learners' algebraic skills and conceptual understanding as a learning difficulty. She also demonstrated knowledge of different teaching strategies used in teaching difficult concepts in the topic. Though she tells learners to practice, it is not clear whether learners are given opportunities to solve problems in the classroom.

5.4.1.3 Teacher's attitudes and beliefs

Martha believes that the personal characteristics of learners have a way of influencing her teaching attitude and classroom practice. She mentioned absent-mindedness as a negative behaviour that affects learners' learning capacity. This was observed when she said, "most learners are absent-minded during the teaching process and as a result they don't do their homework". She also indicated that a learners' home background could possibly contribute to their absent-minded behaviour which in turn affects her classroom teaching. However, Martha's belief on learners' personal characteristics assisted her to develop a teaching approach which is illustrated in the next conversation.

> ***Researcher:*** *Okay so when teaching these learners how do you know that a learner understands your teaching or has successfully overcome the difficult concept in this knowledge area?*
>
> ***Interviewee:*** *Eeem it's very difficult. Eeem in my class I work on the question and answer basis. So generally, what I do is I pick learners randomly to answer a question especially learners I notice are not paying attention. I have been doing this from January and at this stage, I felt that the concentration level in my class has increased because they are all scared I am going to pick on them to answer questions and they don't want to feel bad in front of their other classmates. So, I think this has been effective in the aspect of learners' concentration.*

Though Martha indicated that she developed a teaching attitude which influenced her learners' learning positively, it was not clear if Martha understood how her learners overcame their learning difficulties. However, it seems the teaching attitude had a positive impact on her classroom practice.

5.4.1.4 Contextual factors and challenges

In Section 5.4.1.1, Martha revealed that finding time to collaborate, and poor communication between the district and the school hinders her from collaborating with colleagues outside her school. She also mentioned learners' poor mathematics knowledge as one of the major challenges that affects her teaching. She stated that most physical sciences learners offer mathematical literacy instead of mathematics, because the Department of Education had instructed teachers to allow physical sciences learners enroll for either pure mathematics or mathematical literacy. Martha believes that taking mathematical literacy and physical sciences as subject combination affects learners' performance and application of mathematical knowledge in problem-solving tasks.

> ***Researcher:*** *Looking at these learners' difficulties how does it affect your classroom practice when teaching?*
>
> ***Interviewee:*** *Uhm definitely a lot. The biggest problem for me here is like teaching two subjects in a class before I can teach them any calculation aspect of physical sciences I have to first teach them the basic maths needed before doing the science aspect of my subject so for me it takes my time. And this is the problem with most of my learners since they don't understand or know simple maths. So, each time I do these maths and science teaching together in my class I tend to get lost somewhere in the middle of the whole process…smiling.*

Martha believes that learners lack the basic mathematical knowledge required in understanding some physics concepts. So this eventually affects her teaching time since she must go back to teach the mathematical concept that learners need to apply rather than teaching the planned physical science concept. Though she is aware of the general methods used in teaching, her response shows that she sometimes becomes disorganised on the pedagogy to use when teaching some mathematical problems. It seems Martha's mistake is that she wants to first do the mathematics before teaching the required physics concept. This indicates that she has a poor pedagogical content knowledge and this could compound learners' difficulties in the topic.

5.4.2 Alex's initial interview

This interview was conducted on Monday the 24th of April 2017 in the teacher's staffroom at Roderick high school from 14:10 till 15:25 in the afternoon. The environment was quiet and conducive to conducting the interview.

5.4.2.1 Teacher's collaboration prior to Lesson Study

During the interview, Alex indicated that he is finding it difficult to teach the content on Grade 11 electromagnetism and Grade 12 electrodynamics. A question was asked on how Alex collaborated with his colleagues to address these topics that appear challenging to him.

> ***Researcher:*** *Do you discuss any of these challenging topics with your colleagues inside or outside the school?*
>
> ***Interviewee:*** *I don't discuss it much with anybody because am not open to asking so I just try and look for more resources to read and prepare myself before going to class. However, I have a colleague from another school who we sometimes discuss things like this together in terms of past exam questions and all that but unfortunately, we don't go in-depth as regarding learners' difficulties.*

Alex prefers self-study and use of the online resources to clarify his understanding of difficult concepts encountered as a teacher, rather than discussing it with his colleagues. His response also reveals that he does not engage in thorough interaction focused on learners' challenges. The researcher probed further on how often he collaborated with other teachers through professional development training and workshops. He responded, "In my first two years, I attended quite a lot of workshop on chemistry but after then I will say not so much probably once a year". Elaborating on his answer, Alex indicated that the school sometimes allowed teachers to attend practical training organised by some universities and professional bodies when there was a budget for such training. It seems Alex has not attended any collaborative activity focused on physics since he started teaching physical sciences. However, his response on the budget will be discussed in detail in Section 5.4.2.3 as it relates to contextual factors and challenges rather than teacher collaboration.

5.4.2.2 Teacher's knowledge

Alex demonstrated his knowledge of learners' difficulties in electricity and magnetism when he explained that learners across the FET phase are still finding it difficult to understand the concept of an electric circuit. Further clarification into his understanding of learners' difficulties is shown in the conversation below.

> ***Researcher:*** *Okay, since you have experience with Grade 11 and 12, what are the difficult concepts in electricity and magnetism at this grade too?*
>
> ***Interviewee:*** *In Grade 11, the major problem is electromagnetism. You know there is no detail explanation on the connection between electricity and magnetism, so you just teach the relationship based on textbooks and learners still can't comprehend the relationship between the two. Understanding magnetic flux and the magnetic field strength is very much confusing to learners because it's closely related. Learners also struggle with this concept of induced magnetic field, left-hand rule, and right-hand rule. Then for Grade 12, I will say sometimes learners struggle with the concept of generators.*

Alex's response revealed his knowledge that learners' difficulties in electricity and magnetism are peculiar to the different grade levels. However, it seems that Alex has a conceptual focus on learners' challenges in electricity and magnetism. During his explanation on strategies employed in teaching difficult concepts, he said: "*to be honest I do a lot of explanations, examples, use simulations and analogies to teach sometimes"*. This implies that Alex is aware of different instructional strategies used in teaching and he indicated that he occasionally uses them. This could mean that Alex uses more traditional teaching techniques than practical activities. Also, it is possible that Alex's awareness of learners' difficulties has helped him to develop other ways of integrating his content knowledge to enhance learners' understanding of difficult concepts. Meanwhile, he sounded confident about his way of teaching when he said his "teaching method has been quite effective due to the use of lots of pictures and internet materials" in facilitating learners' learning. Later in the interview, Alex was asked how often he exposed his learners to practical activities when teaching physics concepts. He responded:

> ***Interviewee:*** *Basically, I follow the CAPS document and since the time required to teach scheduled topics in the syllabus is not sufficient, learners only do practical experiments on electric circuit as prescribed but I make sure I do some demonstrations on concepts like magnetic field and I also use pictures on PowerPoint to show them some basic instruments.*

Alex did not clarify the extent to which he engaged his learners in hands-on practical activities. He mentioned that he did not give opportunities to learners to conduct extra practical experiments due to the time allocated to teaching the subject, instead he does demonstration. This does not mean that Alex does not have required practical knowledge in teaching the subject, even though he mentioned that he used demonstration more than hands on experiments to explain some concepts. However, it is not clear if Alex's practical demonstrations result in better teaching, or improve learners' performance and conceptual understanding.

5.4.2.3 Teacher's attitudes and beliefs

Alex believes that learners are supposed to ask questions when they don't understand. His practice differs from the accepted pedagogy where teachers are always expected to ask questions after their teaching in order to assess their learners' understanding of what has been taught.

> ***Researcher:*** *Okay, when teaching in the class what do you look out as evidence of student learning?*
>
> ***Interviewee:*** *I try to make an open communication in my class when discussing or teaching any topic. So, I expect them to ask questions for clarification on what they don't understand. I also give them short test between five and ten minutes, they switch for marking as I do the correction and sometimes I go through the short test just to see if they followed the standard of marking.*

It seems that Alex believes in using formal assessment strategies to assess his learners' learning, but his response reveals that he has a negative attitude towards marking learners' assessment probably because of time. He also uses cooperative learning activities to assess his learners' understanding of the lesson taught. It seems Alex's decision on using cooperative learning activities helps in promoting learners' positive attitudes towards doing their homework and teacher's teaching attitude.

5.4.2.4 Contextual factors and challenges

Alex believes that learners' challenges affect his classroom practice. This was observed when he mentioned that he spends more time providing learners with the opportunity to understand a concept than the scheduled time for the actual teaching.

> ***Researcher:** Do these learners' difficulties and misconceptions affect your classroom teaching or practice in any way?*
> ***Interviewee:**Yes it does because it takes my time, I have to explain over and over and you find out sometimes I waste most of the lesson period on motivation and explanation; not teaching the planned lesson.*

He also indicated how learners' negative attitude towards homework slows down his teaching periods. He said:

> *Another thing is that when you give them homework most of them don't do it and they tell you it's because the homework is difficult so you end up doing the homework for them and this takes like half of your teaching period since you have to explain to make sure they understand the homework So you see this is a problem…. their attitude to homework. (Alex, interview).*

During the interview, Alex also commented on how lack of support towards a professional development programme affects his classroom practice. He said, "I have not attended any professional development programme for the last three years because the school does not have a budget". It seems Alex believes that the school should be responsible for teachers' professional development.

5.5 First planning session by Lesson Study pair B

The first Lesson Study meeting was held between the hours of 14:30 and 15:30 on Thursday the 4th of May at Alex's class at Roderick high school. At the beginning of the meeting, teachers were asked to present a copy of their original lesson plans. Martha presented a ready-made lesson plan supplied by the department and Alex presented scribbled notes as his lesson plan. The lesson plan presented by both teachers did not capture the criteria for an effective lesson plan as required for this Lesson Study intervention. So, teachers were requested to write lesson plans for all research lessons using the provided Lesson Study plan template by the researcher. Both teachers were given an electronic copy of the Lesson Study plan template in Appendix 8. They also agreed to share responsibilities among themselves. Alex agreed to write the lesson plan for the first research lesson. As the meeting continued, both teachers agreed to use a specific textbook for their lesson preparation based on the conversation below.

> ***Martha:*** *You know the doc Scientia textbook captures basically what the learners need to know and follow the step by step process of what the CAPS documents entail. And I sometimes use the DVD of the textbook which makes my teaching convenient.*
>
> ***Alex:*** *Personally, I still prefer using Doc Scientia because it presents the content in simple English and according to the CAPS curriculum. The school also recommends Doc Scientia because it contains both learners' workbook and textbook in one*.

They also indicated that they have the appropriate laboratory equipment to teach concepts in electricity and magnetism. Alex emphasized the importance of aligning all research lessons to the CAPS document, as they discussed the sequence of the lesson for the term. The teachers planned their first research lesson on magnetism. The teachers deliberated on the importance of reviewing and recalling what learners know about magnetic materials, nonmagnetic materials and the classification of matters based on their Grade 9 natural sciences and Grade 10 first term chemistry. Martha recommended the use of oral questions and answers in assessing learners' prior knowledge and understanding of the lesson to be taught. During the brainstorming session, both teachers revealed that learners don't struggle with magnetism. However, Martha later indicated that some learners find it very difficult to draw patterns of the magnetic field despite practical demonstrations. Alex stated that practical demonstrations focused on learners' observation alone might not be helpful. He suggested that learners should be asked to observe, draw and explain their observation, as they compared it with diagrams in their textbooks. He said:

> **Alex:** *I believe that learners' ability to observe and draw will help them visualise the existence of magnetic field lines and also enhance their understanding on how to identify North and South poles of magnets and know the basic characteristics of a field line.*

Both teachers agreed to use group practical demonstration and discussion strategy in enhancing learners' understanding of difficult concepts in this lesson. Teachers also discussed and highlighted important points that learners had to be acquainted with.

The teachers declared that there was not much to discuss on magnetism as a topic, so the meeting was concluded by asking the teachers to take note of important points discussed as they taught the research lesson in their respective classrooms. A picture of both teachers explaining concepts to each other during the planning meeting is portrayed in Figure 5.1.

Figure 5-1: Lesson Study pair B teachers explaining the lesson to each other during one of the Lesson Study meetings.

5.6 Classroom observation for the first lesson

5.6.1 Alex's first lesson presentation

Alex's lesson on Grade 10 magnetism was presented on Friday the 5th of May from 9:15 a.m. until 11: 20 a.m. Alex welcomed the researcher and introduced her to the learners. The researcher was assigned me a chair at the back of the class where the teacher and the learners could be observed. Alex placed a small container filled with iron filings, A4 paper, bar magnets and compasses on a table in the middle of the classroom before the commencement of the lesson. He started his lesson by using questions to assess what learners already knew about magnetism as discussed in the planning meeting and indicated in the lesson plan in Appendix 20.

Teacher: *What is magnetism and how does it occur?*

Learners: *A substance with an ability to attract another substance in a region where the magnetic field is felt.*

Teacher: *How do we know that there is a magnetic field around a magnet?*

Learners: *We imagine the reaction between two magnets the moment an attraction or repulsion is felt at a specific point.*

Alex used oral questions at the beginning of his lesson to promote open discussion among learners as discussed in the planning (see Appendix 20). As the teaching continued, Alex indicated that nickel, cobalt, and iron are the three magnetic metals in the periodic table. Alex instructed the learners to gather around the table with equipment as he demonstrated how a magnetic field is created using magnets and iron filings. During the practical demonstration, learners were asked to observe, draw and explain their observation and compare their diagrams to what is in the textbook. A picture of one of the learners drawing her observation is shown in Figure 5.2.

Figure 5-2: Learners in Alex's class drawing out magnetic field lines as observed during teacher's demonstration

The practical demonstration was conducted in accordance with the activities planned for learners during the Lesson Study planning session. As the demonstration continued, Alex described field lines as continuous imaginary lines conventionally represented with solid or dotted lines. He placed some compasses next to the magnet and learners indicated that the compass needles had two different directions. Alex identified the directions as a North and South pole. He explained the properties of magnetic field lines indicating that they are three dimensional in nature, never cross each other, very close to one another, always start on the object and end on the magnetic object. During his explanation on magnetic field lines, a learner asked: "why is that the field lines are more concentrated at the pole?". Alex replied "when field lines are closer or more concentrated at the pole, it means there is stronger magnetic field and when they are further away it means weaker magnetic field". A pictorial representation of Alex's demonstration on magnetic field lines is shown in Figure 5-3.

Figure 5-3: Alex's class demonstration on the direction of magnetic field lines using a compass.

Alex also demonstrated how learners can create a temporary magnet by rubbing a piece of magnet on another metal object in one direction. During his demonstration, he said, "while creating a magnet, each domain will have to spin in the different direction". Learners were asked to describe a domain and they responded by saying "a domain is a spin of electron". Alex corrected the learners by describing a domain as a "region in which all electrons are spinning in the same direction for a magnetic object". Every time Alex introduced a new concept, he wrote major points and definitions on the board. Learners were given a few minutes to write down the notes in their books. As the teaching continued, he described ferromagnetic materials as materials that retained their magnetic properties once magnetised. A learner asked: sir, do you have to magnetise iron before it works?" Alex responded by saying "yes, if you are a making a magnet, but you can sometimes find iron as naturally magnetised". Alex assessed learners' understanding of the lesson by asking verbal questions. He applauded the learners for answering the questions correctly. Alex used terminologies like magnetosphere, solar wind and Aurora to explain concepts related to the earth's magnetic field. During Alex's explanation on the earth's magnetic and geographic poles, learners laughed and made funny comments about North Africa and South Africa. Alex used a PowerPoint presentation to illustrate how a stream of charged particles in the solar wind moves out from the sun's upper atmosphere towards the earth. He also played a video which demonstrated the aurora activity that took place in 2014 in the North of Scotland. Alex wrote some notes on the board for learners to copy into their books. Learners were asked to answer the questions in exercise 9 of their doc Scientia workbook as a class activity. After few minutes, learners were instructed to mark their answers. Alex concluded the lesson by writing the answers on the board. The bell rang to signal the end of the period. A sample of Alex's notes written on the board is shown in Figure 5.4.

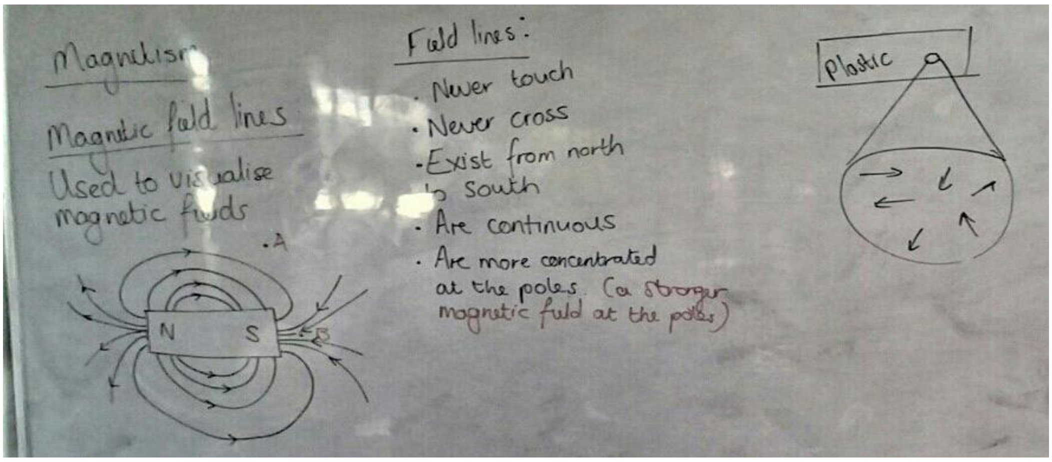


Figure 5-4: Alex's class note on magnetic field lines written on the board for learners.

A sample of one of the learners' workbook activity during Alex's class on magnetism is shown in Figure 5.5.

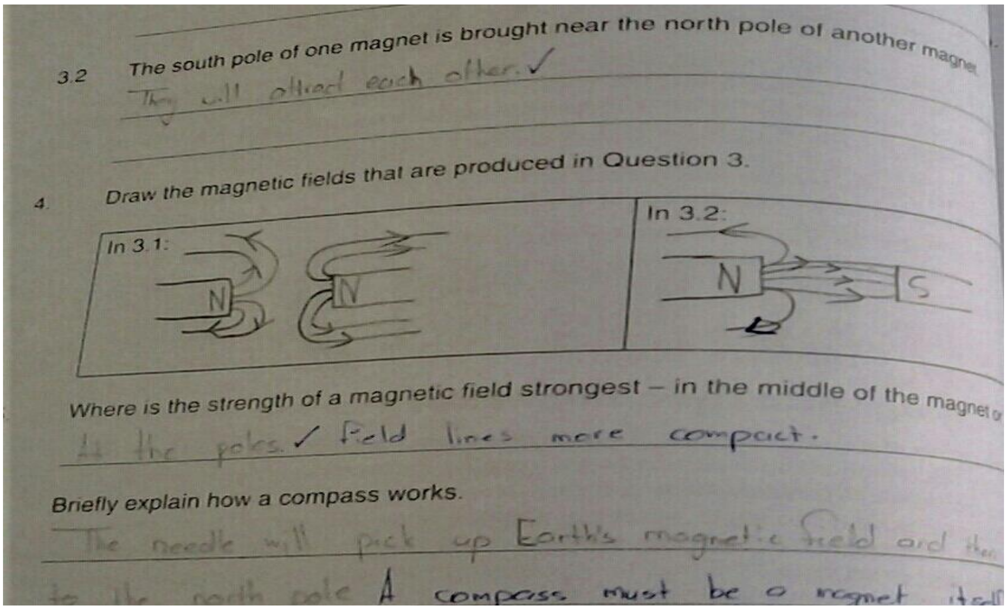


Figure 5-5: One of the learners' workbook in Alex's class during class activity on magnetism.

5.6.1.1 Analysis according to observation schedule for lesson 1

Assessing learners learning

During his lesson introduction, Alex assessed learners' previous knowledge by using the teacher directed question and answer approach. He asked learners to define magnetism based on their previous knowledge from their first-term work on the topic matter. He also assessed learners' practical knowledge by asking them to explain what was observed during the teacher's demonstration on magnetic field lines. Alex checked for learners' understanding of the lesson taught by engaging them in an interactive session which did not require him to keep asking if learners understood or not.

Instructional delivery

During Alex's lesson presentation, his method of introduction which involved the placing of magnets and compasses on the table evidently showed that the topic was related to magnetism. Alex's lesson was presented according to the planned objectives outlined in the Lesson Study plan template. He used various teaching strategies like demonstration, explanation, and question and answer to enhance his learners' understanding of the lesson. Alex encouraged individual/independent work among learners by asking learners to observe, draw and explain what was observed during the teacher's practical demonstration on the magnetic field lines. However, no small group or paired activities were done in this lesson, since learners were only given the opportunity to observe their teacher's demonstration on how a magnetic field was created. Alex adequately responded to learners' questions thereby clarifying learners' misconceptions and enhancing their conceptual understanding of the topic. He also used a multimedia presentation to enhance learners' understanding of aurorae and the earth's magnetic field. He displayed energy and enthusiasm about the lesson and the learners. He managed the time allocated for the lesson effectively and efficiently.

Classroom interaction

Alex instructed learners to raise their hands and ask questions during his teaching whenever they felt confused. Alex ensured that basic definitions, key points, and diagrams were written on the board for learners' understanding. He managed the disruptive behaviours of learners as learners were quiet and attentive all through the lesson. He used lecturing activities to clearly explain the information that was written on the board. He demonstrated good interaction skills by relating well with his learners. This was observed when he responded appropriately to learners' questions. He supported his learners' learning through demonstration activities and answering of learners' questions. Alex encouraged learners' participation in the teaching and learning process using a teacher directed question and answer approach. He created a good classroom environment for his teaching. This was observed at the beginning of the lesson when he used demonstration activities on magnetic field lines to captivate learners' interest in the topic.

Teachers' knowledge

Alex presented the lesson as planned during the collaborative planning section and his lesson presentation was well aligned to the specified contents in the CAPS document. He demonstrated adequate knowledge of the required concepts in teaching magnetism as a topic. This was also observed during his explanation of the movement and direction of compass needles. He also demonstrated his professional knowledge by asking questions that required learners to express their previous knowledge and thoughts about the new lesson. Alex demonstrated his pedagogical skills and knowledge by using various teaching strategies. During his practical demonstration, he asked questions that promoted learners critical thinking skills. This was observed when learners were required to observe, analyse, draw and explain what they saw in the teacher's demonstration. Alex showed empathy towards learners' inability to answer questions on the characteristics of magnetic field lines by providing answers as corrections to activities in learners' workbooks. He ensured that feedback was appropriately given by answering learners' questions. It seems that Alex was committed and enthusiastic about learners understanding of the lesson content.

5.6.2 Martha's first lesson presentation

Martha's lesson presentation on magnetism took place on Tuesday the 9th of May from 7:55 am to 8:35 am. Martha welcomed and introduced the researcher to the learners. She requested learners to be well behaved during the lesson. She started her teaching by introducing the topic as she opened her laptop and turned on the projector. She assessed learners' knowledge of magnetism as discussed during the planning session and referred to the lesson plan through the following conversation.

> ***Teacher:*** *What is a magnet?*
>
> ***Learners:*** *Substance that has the ability to attract other substance to itself*
>
> ***Teacher:*** *What is a magnetic field?*
>
> ***Learners:*** *No response*

Martha used the teacher directed question-answer session to promote open discussion among learners as deliberated during the planning session. Martha distributed a magnet and a string of thread to the learners. Learners were asked to tie the thread to the piece of a magnet as they explained their observation. One of the learners indicated that the magnet was pointing to the North direction. Martha explained how learners can determine the polarity of a magnet by suspending a bar magnet on a string. She indicated that a free hanging magnet will always point in the North direction. A learner asked, "does that mean that a compass is also a magnet since it is always moving in the North direction?". Martha responded, "a compass is not a magnet but it runs according to the magnetic field of the earth". Her response showed a gap in her own content knowledge because the compass has a magnetic needle which is attracted by the Earth's magnetic field. A learner entered the lab and interrupted the teaching process. Martha spent about ten minutes rebuking the learner for coming late for class. As the teaching continued, Martha explained the law of magnetism by indicating that like poles repel each other and unlike poles attract each other. She emphasised that learners must know basic definitions and laws word for word since marks will not be awarded freely during the examination. Martha used PowerPoint to present the content knowledge of the topic to learners. She read the definition of magnetic field from her slide and explained to learners. A sample of Martha's PowerPoint slide is portrayed in Figure 5.6.

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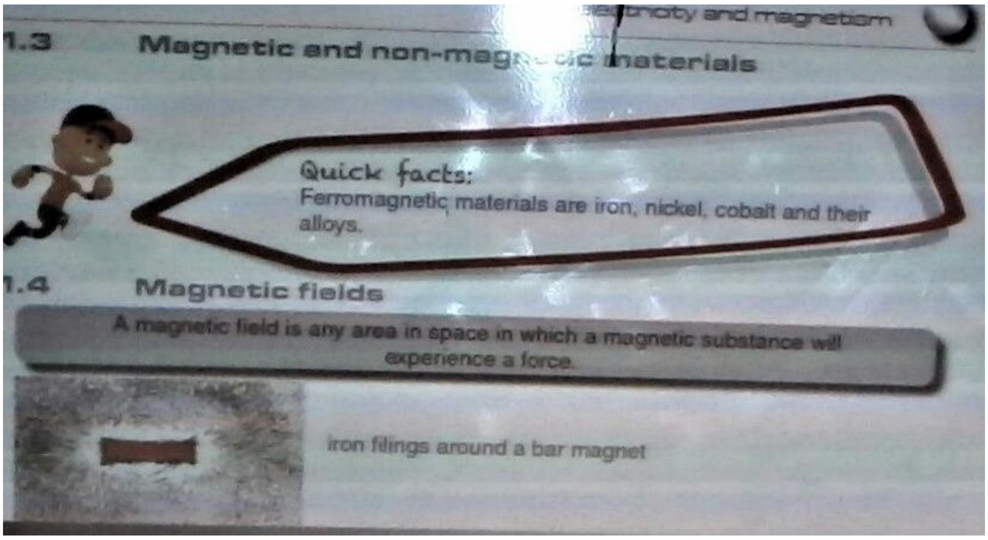


Figure 5-6: Martha's Power Point presentation on magnetic field

Learners were requested to follow the teacher's instruction as they demonstrated, observed and explained their observation in a group practical activity on the magnetic field, as Martha demonstrated the activity at one of the group tables. During the activity, verbal questions were used to assess learners' awareness and knowledge of chemical symbols. During learners' explanation of what was observed, they indicated that the field lines looked like a rainbow and the iron filings at the end side of the magnet looked like small spikes in them. Martha explained the observed spikes as an indication that a magnetic field is three dimensional in space even though it is drawn as two dimensional. A picture of learners performing a practical activity on magnetic field patterns is shown in Figure 5.7.

Figure 5-7*: Learners in Martha's class doing a practical activity on magnetic field lines.*

Martha indicated that learners must know the following magnetic rules when drawing the direction of magnetic fields. She said:

> **Teacher**: *You must always know that magnetic field lines are continuous, imaginary, three dimensional in space, run from the North to the South, never cross or touch each other, more concentrated at the poles and the strength of a magnet is always stronger at the poles than the middle of the magnet.*

Martha presented a slide on the difference between magnetic field, electric field, and gravitational field. She asked learners to copy the slide in their books as she explained the differences. She enhanced learners understanding on how to draw magnetic field lines This was observed when she emphasised the following points:

- It is better to draw two to three curves rather than drawing a bunch of lines that make your drawing dirty and clumsy.
- Learners should draw a few lines and get more marks rather than draw a bunch of lines and lose marks.
- Magnetic lines don’t touch, so diagrams will be marked wrong if learners mistakenly draw their lines touching.
- Field lines must be more at the poles than at the centre.
- Learners should always indicate which side is North and which side is South with an arrow when drawing their magnetic field lines. Remember they are moving from North to South and not otherwise.

After explaining the important points, she asked learners to draw the pattern for a single bar magnet, magnetic field lines between two magnets of the same pole and opposite poles inside their workbook or writing book. Learners were required to call the teacher’s attention in case they don’t know how to draw the patterns. The bell rang to end the lesson and Martha told learners that the activity will be concluded in the next class since learners are to observe the field patterns and draw them. A picture of Martha explaining the observed magnetic field line pattern to learners is shown in Figure 5.8.

Figure 5-8: Martha explaining magnetic field lines to learners during the practical activity

5.6.2.1 Analysis according to observation schedule for lesson 1

Assessing learners learning

At the beginning of the lesson presentation, Martha assessed learners' previous knowledge on the propagation of electromagnetic waves using question and answer. The question and answer approach created an opportunity for learners to be involved in the teaching and learning process. Martha also assessed her learners' learning by engaging them in a whole class discussion since learners were asked to observe and explain the magnetic field patterns. She repeatedly checked for learners' understanding of the lesson taught by frequently asking if learners understood what she was saying. She also instructed learners to call for her attention whenever they did not understand her explanation.

Instructional delivery

Martha presented an overview of the lesson using a multimedia presentation. Her lesson was presented according to the planned objectives. She clarified learners' difficulties by responding to questions asked before proceeding with her teaching. However, her explanations were not always correct. This was observed when she provided the correct answer to the question on the chemical name for solid iron as Fe and not Fe_3 as learners have previously answered. She integrated a few examples from the real world into her lesson. This was noticed when Martha explained the location of Polokwane to enhance learners' understanding of directions of North and South. She also emphasised important points such as definition and characteristics of a magnetic field during her lesson presentation. Martha used basic illustrations and relevant activities on her multimedia presentation to clarify difficult concepts that appeared confusing to learners. She also engaged learners in practical group work.

Classroom interaction

Martha's lesson was presented through multimedia, this enabled her to project key vocabulary used in her teaching on the board. She demonstrated various pedagogical skills such as explanation, practical demonstration followed by group work, note review and drawings during her lesson delivery. This helped her to relate the lesson well to learners. Her multimedia presentation captured learners' interest and this made the classroom environment conducive to learning. Learners' disruptive behaviours were well managed by the teacher, as learners remained quiet and attentive during the teaching process. Martha also allowed learners to play with real magnets as a method of creating an environment of interest for learners during her teaching. Martha's classroom interaction was also assessed through her use of a learner participation approach in the teaching process. This was observed when she involved the learners in a group practical activity and allowed them to discuss what they had observed. She also used the questioning method of teaching to build a positive relationship with the learners. She encouraged independent work among learners and engaged learners in paired activities to enable them to share their answers with each other.

Teachers' knowledge

Martha demonstrated acceptable knowledge of most of the subject matter during her teaching. This was observed during the presentation of the lesson overview as she confidently explained the key terms and concepts, even though she repeatedly read out her notes from the slides before explaining. However, she demonstrated a poor understanding of the content knowledge when she indicated that a compass is not a magnet. She demonstrated her practical knowledge of the required experiment needed in teaching magnetic field lines since she involved learners in her demonstration. Her ability to repeatedly instruct learners to ask a question if they did not understand showed that she was committed and enthusiastic about her learners' learning. She also showed empathy towards her learners' challenges by correcting learners' mistakes based on questions that were asked and providing accurate feedback on learners' homework.

5.7 **Second Lesson Study meeting by pair B**

5.7.1 First reflection session by pair B

The second Lesson Study meeting was held in Duncan secondary school on the 11th of May at 2:30 pm. The teachers watched a video recording of their lesson presentations on magnetism. After the observed video, the researcher asked teachers to explain whether their learning objectives were met. Alex indicated that his lesson objective was achieved. He believes that his lesson on magnetism was quite successful since most of the learners scored four out of five from the short test he conducted. Martha indicated that learners were able to physically see a magnet and visualise what field line looked like. She believed that the lesson was very basic and that learners understood quite well.

The two teachers also reflected on the strengths of their teaching. Both teachers indicated that the strength of their lesson was allowing the learners to investigate, observe, draw and explain practical activities on magnetism. However, Alex indicated that he could have stressed the point that what creates magnetism is a moving charge. Martha also indicated that she would have preferred to demonstrate the practical activity at the beginning of the lesson, but that would have diverted learners' attention. She believes that learners' attitude and behaviour during the practical experiment make them lose concentration as the teaching progresses. Elaborating on the strengths of their lessons, Alex reflected on how the practical demonstration promoted collaborative discussion among learners. However, he realised that the lesson could be improved by changing his teaching method. He said,

> *One thing I did not pay a lot of attention to was basically showing the different kinds of object that is magnetic and which is not magnetic I just kept on stressing on iron, nickel, and cobalt which are ferromagnetic. I have never really had the time to let them play around with pieces of materials to enable them to check for themselves what is magnetic and what is not magnetic…. Yea so*

otherwise I think the teaching on that was sort of superficial which I might likely try to change when next I am teaching that concept.

It seems that Alex realised the importance of engaging learners in hands-on practical activities to promote their conceptual understanding. This could be a personal reflection on what Alex has learned from participating in this study. On the other hand, Martha reflected on time constraints as a challenge faced when engaging learners in practical activities at the beginning of a lesson. It seems Martha was concerned about the teaching period allocated to the subject. She believed that the introduction of practical activities at the beginning of a lesson tended to make learners deviate from the aim of the lesson. Alex suggested that teachers should strike a balance with when and how to engage learners in practical activities during teaching time since learners are not the same. Alex reflected on the challenges encountered during the first research lesson plan writing. He indicated that the Lesson Study plan template provided was different from the lesson plan templates he was familiar with. Martha also reflected on her classroom practice. She said,

> *You know, though I normally do this demonstration with learners but not asking them to observe, draw and explain what they saw. I observed that the learners were able to immediately relate the concept to a general view of how some environmental issues are linked to the application of physical science concepts. (Matha, interview).*

Martha's content knowledge gap about a compass not being a magnet was not noticed in the video, neither was it discussed during the reflection. However, it seems that her participation in the first meeting improved her practical knowledge and practice. The researcher requested that they write down their reflections and use it to improve their practice when teaching other research lessons.

5.7.2 Second planning session by pair B

Teachers planned their next research lesson on electrostatics. They discussed the lesson content as they outlined important concepts that learners must know. These concepts include charges, forces between charges, distribution of charges, conservation of charges, conductors and insulators. During the lesson preparation, both teachers agreed to use PowerPoint presentations and Phet simulations in enhancing learners' understanding of the topic. Martha emphasised the importance of differentiating between types of charges and poles. She believes that most learners are confused about the concepts of electric charges and magnetic poles. Alex recommended the use of simple examples common to learners in explaining the concept of static electricity. He said,

> *"I think it is better to use this illustration on how sparks are being given off in form of charges during the process of taking off their jerseys during winter or dry season as an example."*

Martha developed the lesson plan as shown in Appendix 20 and Alex wrote a mind map of what the lesson entailed as presented in Figure 5.9.

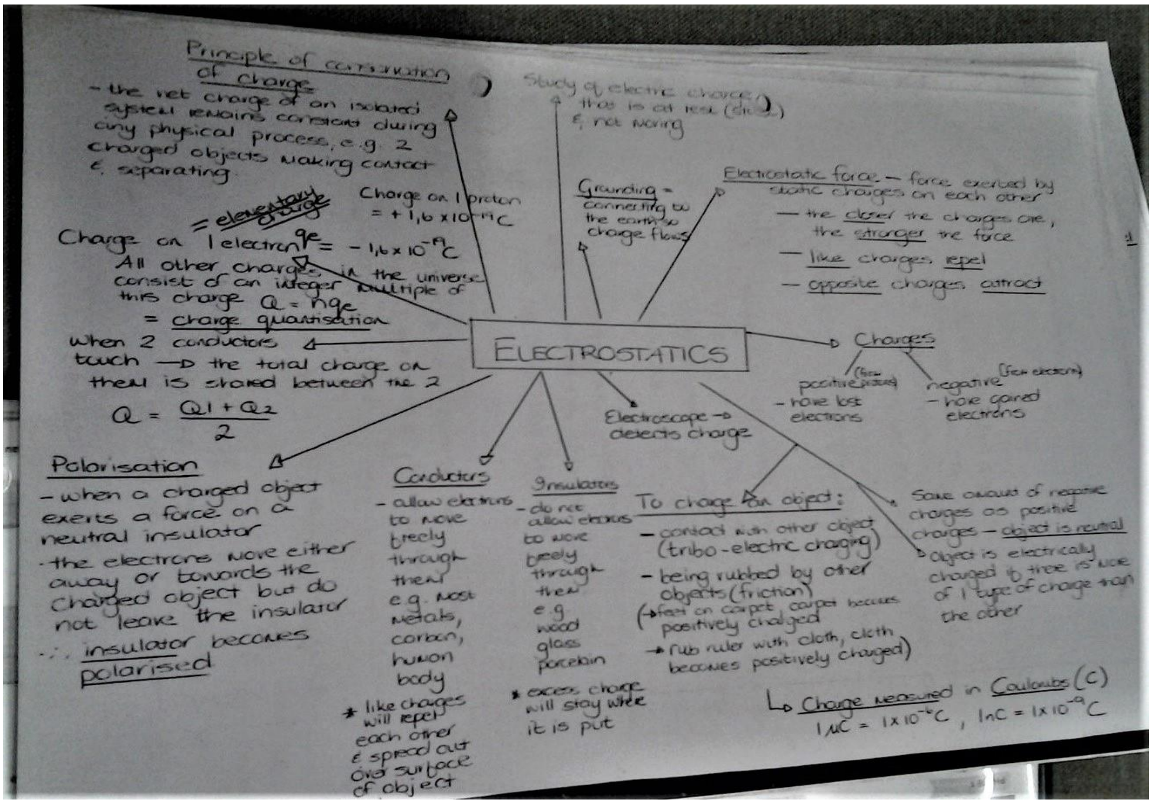
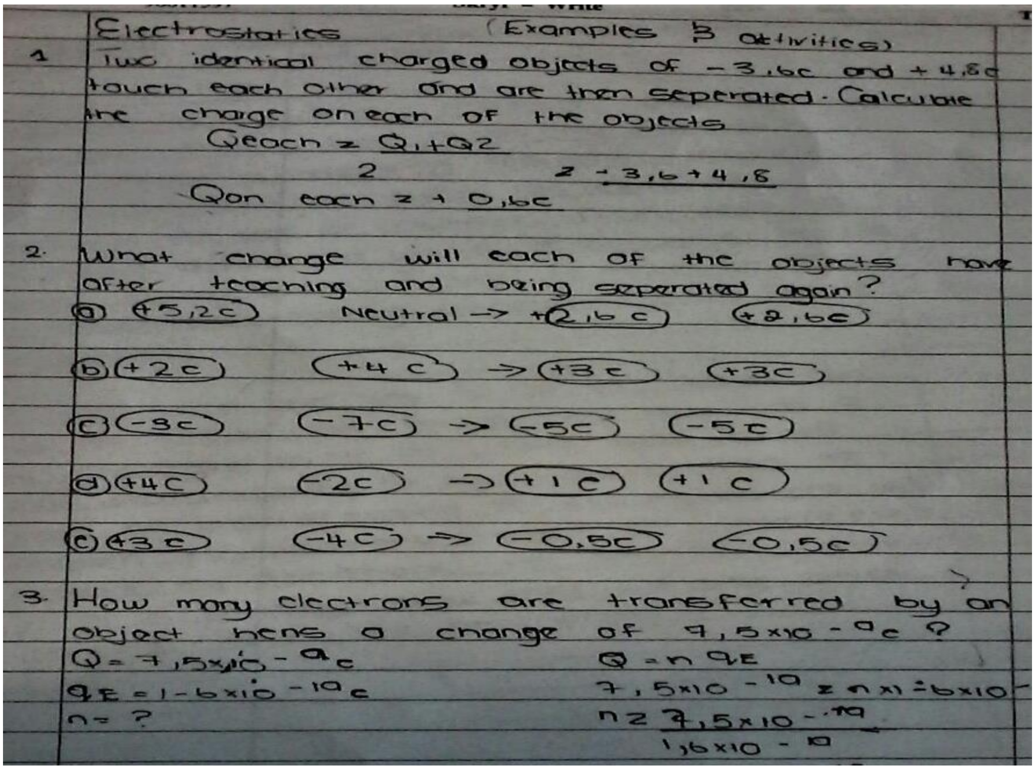


Figure 5-9: Lesson Study pair B's mind map for the lesson presentation on electrostatics during their second planning meeting

Teachers also reviewed several problem-solving examples from the textbook and solved few questions together. Alex pointed out that learners must know and be able to write out the formula for finding the charge of an object which is $Q = n\, q_e$. He believes that learners must know the meaning of each symbol, for instance, Q = charge of an object, n= number of electrons and q_e = charge of an electron with a constant value of

$-1.6x\ 10^{-19}C$. However, it was observed that teachers did not consider using simple objects that are readily available like balloons and plastic rulers to explain the concept of electrostatics. A sample of the problems they solved together is shown in Figure 5.10.



Electrostatics (Examples & activities)

1 Two identical charged objects of -3,6C and +4,8C touch each other and are then seperated. Calculate the charge on each of the objects

Qeach = (Q1+Q2)/2 = (-3,6+4,8)/2

Qon each = +0,6C

2. What change will each of the objects have after teaching and being seperated again?

(a) +5,2C Neutral -> +2,6C +2,6C

(b) +2C +4C -> +3C +3C

(c) -3C -7C -> -5C -5C

(d) +4C -2C -> +1C +1C

(e) +3C -4C -> -0,5C -0,5C

3. How many electrons are transferred by an object hens a change of 7,5x10^-9 C?

Q = 7,5x10^-9 C Q = n qE

qE = 1,6x10^-19 C 7,5x10^-9 = n x 1,6x10^-19

n = ? n = 7,5x10^-9 / 1,6x10^-19

Figure 5-10: Pair B’s problem-solving examples during their second Lesson Study planning meeting

5.8 Classroom observation for the second lesson

5.8.1 Alex’s second lesson delivery

Alex’s lesson presentation on electrostatics took place on a Monday from 7:55 am until 8.05 am. The lesson started with a question and answer session as portrayed below.

Teacher: *Yes what do you think electrostatic is all about?*

Learner 1: *It is the build of electricity on a circuit.*

Learner 2: *It is all about friction.*

Learner 3: *Sir, I think electrostatics has to do with electricity in a static position.*

Teacher: *What does static means?*

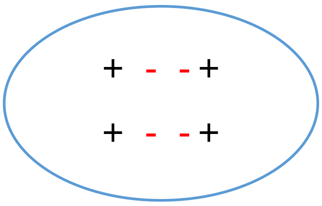
Learner: *Stationary*

Teacher: *What creates electricity?*

Learner: *Moving charges*

The question and answer session revealed how Alex effectively led the discussion to improve learners' understanding of how static and current electricity are different. He revised the concept on types of electricity which learners were already taught in Grade 9 Natural sciences. He explained the difference between current and static electricity. He also explained the concept of electrostatics using scientific terms. He used oral questions to assess learners' knowledge on parts of an atom and types of charges. Learners were asked to give examples of stationary charges. One of the learners said, "*sometimes when we rub our shoes on a carpet and then touch objects that are metallic in nature one will observe some things in a spark form*". Alex applauded the learner and pointed out observation of sparks when pulling off a wool jersey during the winter season as another example. As the teaching continued, Alex explained the concept of net charge as the overall charge in an object. He solved a few examples using three different diagrams on the board which are as follows:

Object 1

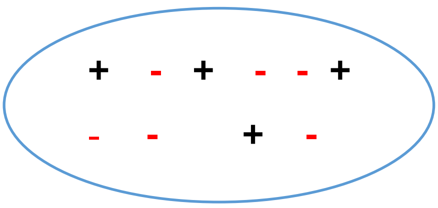


Object one has four positive charges and four negative charges. What is the overall charge of the object?

Net charge = P + (-E).

P is the number of positive charges or protons and N is the number of negative charges or electrons in the nucleus of an atom. So, net charge =4 + (-4) = 0. This implies that the object is neutral (same number of positive charges as negative charge).

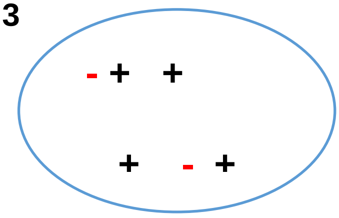
Object 2



Object 2 has four positive charges and six negative charges. Calculate the net charge. Learners echoed "-2" as their answer but were unable interpret their result. Alex interpreted the answer by saying:

> "When the total net charge of an object is negative, it indicates an excess charge. The question on object two implies that the object has an excess of 2 negative charges".

Object 3



Object three has four positive charges and two negative charges. Calculate the net charge.

Learners gave their answer as "+2" and explained that the object has an excess of two positive charges. Alex corrected the learners' response and said, "if the overall charge in an object is positive, it implies that the object is deficient of 2 negative charges". Next, Alex spent about twelve minutes attending to a situation outside his class. As the teaching continued, Alex explained the process of electron transfer using triboelectric series and triboelectric charging. He distributed a paper containing a list of materials in the triboelectric series. Learners were asked to identify materials that are likely to lose or gain electrons in the list. He used verbal questions to assess learners' understanding of the lesson. He explained the three methods of charging an object. The methods were friction, contact, and induction. Alex indicated that friction and contact involve the giving or taking of electrons to make it change, while induction is about giving off an object without gaining or losing charge. He also explained the concept of polarisation as a way of inducing charge rearrangement in conductors and insulators. Alex wrote important notes on the board as shown in Figure 5.11, and learners were given a few minutes to write the notes in their books.

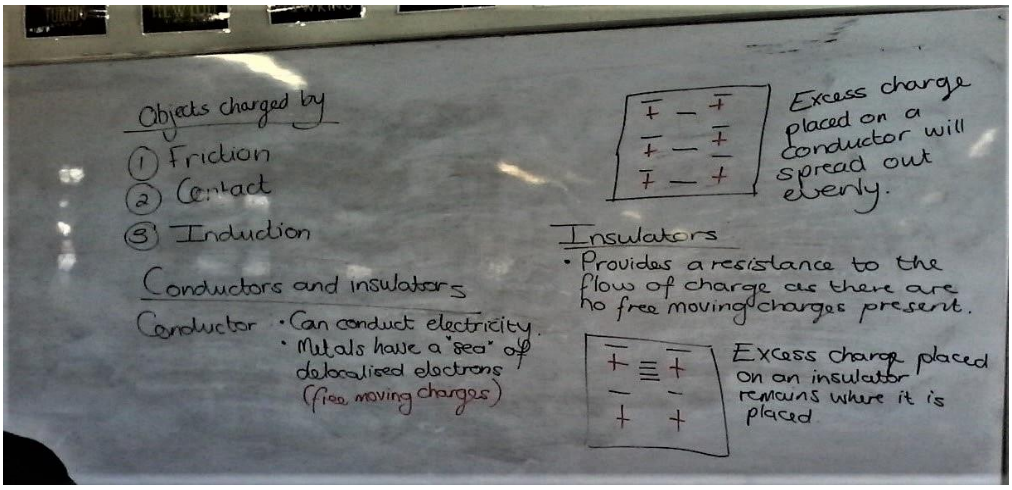


Figure 5-11: Alex's notes on conductors and insulators as written on the board.

Alex demonstrated and explained the concept of charging an object by induction using an electroscope. After Alex's explanation, he gave the learners a short class activity from their workbook and went around to assess each learner's work as a way of ensuring that learners understood what he had taught them. A picture of Alex checking individual learners' class activity is provided in Figure 5.12.

Figure 5-12: Alex working round the class to check individual learners' class activity

5.8.1.1 Analysis according to observation schedule for lesson 2

Assessing learners' learning

Alex assessed learners' previous knowledge by asking questions related to learners' understanding of static and current electricity. He involved learners in a class activity focused on assessing learners' problem-solving skills and interpretation of answers on net charge. He also checked for learners' understanding of the lesson taught by asking questions related to what he was teaching.

Instructional delivery

Alex presented an overview of the lesson by explaining the concept of electrostatics based on learners' response to questions asked. His second lesson was well presented according to the curriculum and Lesson Study plan template design. All outlined lesson objectives were met. He used teaching methods such as illustrations, explanation, lecture method, question-answer method to enhance learners' understanding of key concepts in electrostatics. For instance, he used the explanation method in describing terminologies such as triboelectric series, conductors, inductors, and insulator. Alex ensured that important points were written on the board and he correctly responded to learners' questions. He demonstrated a few practical activities using an electroscope and a metal sphere to enhance learners' understanding of charging by induction and contact.

Classroom interaction

Alex allowed learners to collaboratively solve a few questions as they discussed and interpreted their answers among themselves. Disruptive behaviour was well managed by the teacher since learners were observed to be quiet and attentive as they took down notes. The classroom was effectively managed by the teacher and he related well to the learners. He also created an environment of interest for learners by using concepts of atom and molecules to enhance learners' understanding of charges. Alex supported his learners' learning by encouraging learners' participation in the teaching process. He also encouraged independent textbook activities among learners through classwork and homework. However, no group practical activities were done in this lesson.

Teachers' knowledge

Alex demonstrated adequate knowledge of the concepts required in teaching the research lesson as a representation of his subject matter knowledge. He clearly explained the concepts of a delocalised sea of electrons in matter without errors or mistakes. The lesson content was well presented and well explained to meet learners' needs. He also demonstrated knowledge of various teaching strategies used in enhancing learners' understanding of science lessons. These included illustrations, explanation, lecture method, question and answer method. Alex's use of various teaching methods showed that he was committed and enthusiastic about learners' understanding of the lesson taught. However, the learners did not conduct practical activities on this lesson as indicated in the curriculum but he demonstrated the concept of polarisation by induction using a gold leaf electroscope. Alex also demonstrated his professional knowledge by providing accurate feedback on learners' class work and homework. He also demonstrated his teaching knowledge as he confidently walked around the class to check learners' work.

5.8.2 Martha's second lesson presentation

Martha's lesson presentation on electrostatics took place on the 16th of May from 8:35 a.m. until 9:45 a.m. She welcomed and introduced a student teacher seated at the back of the class to the learners. She started her teaching by revising learners' knowledge of basic chemistry through the following conversation.

> ***Teacher:*** *What do we find in the nucleus of an atom?*
>
> ***Learners:*** *Protons, neutrons and electrons*
>
> ***Teacher:*** *What do we find in the outer orbital of a nucleus?*
>
> ***Learners:*** *Electrons*
>
> ***Teachers:*** *And the electrons at the outermost level are called what?*
>
> ***Learners:*** *Valence electrons*

In Science, protons and neutrons are found in the nucleus of an atom while electrons are found in shells around the nucleus. The conversation portrayed above showed that learners have a poor understanding of particles found in the nucleus. However, it was observed that Martha did not provide adequate feedback on the wrong answer given by learners. This reveals a gap in her content knowledge. Martha indicated that electrostatics also called static electricity deals with charges that are not moving. She revised the basic law of magnetism which was taught in the previous lesson. She related the law of how charges interact, indicating that like charges repel while unlike charges attract each other. She explained the difference between the charge of an object (Q) and charge of an electron (q_e = -1,6 x10^{-19} coulomb). Martha described friction, contact and induction as the three methods of charge distribution. Learners were asked to repeat the methods. Martha explained the rubbing of hands on their clothes and dragging of feet on a carpet as examples of charging by friction. She used guided question and answer to assess learners' knowledge on charge distribution in an atom. A simulation model was presented to show the interaction between charged materials and visualise the outcome of static electricity as shown in Figure 5.13.

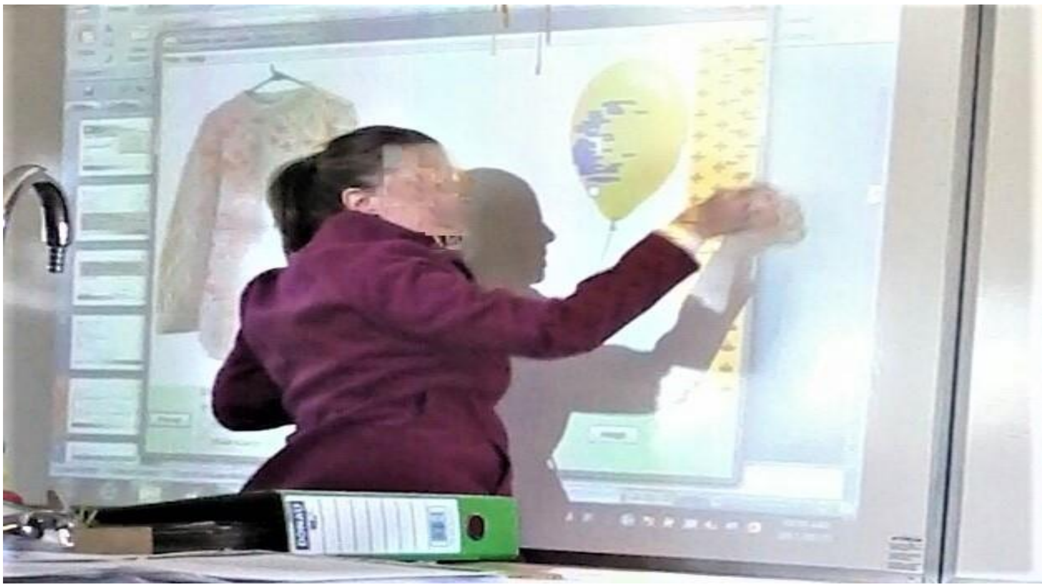


Figure 5-13: Martha explaining static electricity using simulation

As the teaching continued, Martha read the following question from her PowerPoint slide and used the question to explain the concept of charging by contact.

> ***Martha:*** *An object with a charge of -3,6 coulomb touches an identical neutral object. During contact, -1,8 coulomb (half) of the charged object's charge will be transferred to the neutral object and both objects will now have a charge of -1,8 coulomb as seen in the diagram.*

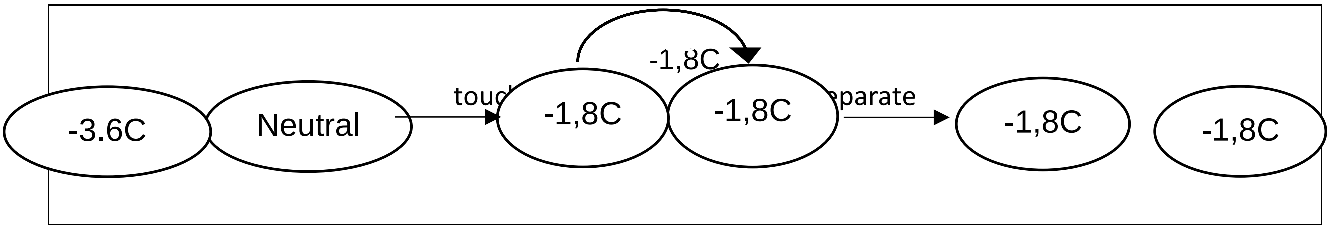


Figure 5-14: Martha's explanation of charging by contact

During her explanation, she indicated that the overall charge on a neutral object is always zero since the object has the same number of electrons as protons and neutrons have no charge. Learners were asked to state the law of conservation of charge. One of the learners responded saying "they always move from negative to positive". Another learner said, "charge cannot be created or destroyed but be transferred". Martha read the law from her PowerPoint slide and told learners to always complete their definitions since it is either a full mark or zero. She explained how electrons are being transferred in spherical bodies from a more negatively charged body to a less negatively charged body. She continued her teaching by demonstrating the concept of charging by contact and induction using an electroscope as displayed in Figure 5.15.

Figure 5-15: Martha demonstrating charging of an electroscope by induction.

Her practical demonstrations were performed according to the activities outlined during the planning. Learners were asked to differentiate between a conductor and an insulator. Martha explained how a conductor becomes polarised when negative charges move towards a charged rod placed on the electroscope. As the demonstration continued, a learner asked: "*where did the positive charges go"*. Martha responded by saying "the charges still remain there but just that only the electrons are transferred". Her response demonstrated that she has a good understanding of the content knowledge. Martha described induction *as* a method of charging whereby the object to be charged does not touch another charged object. She explained a few problem-solving examples from her PowerPoint slide as shown in Figure 5.16. Martha concluded her lesson by instructing learners to answer questions in exercise 10 of their workbook as homework.

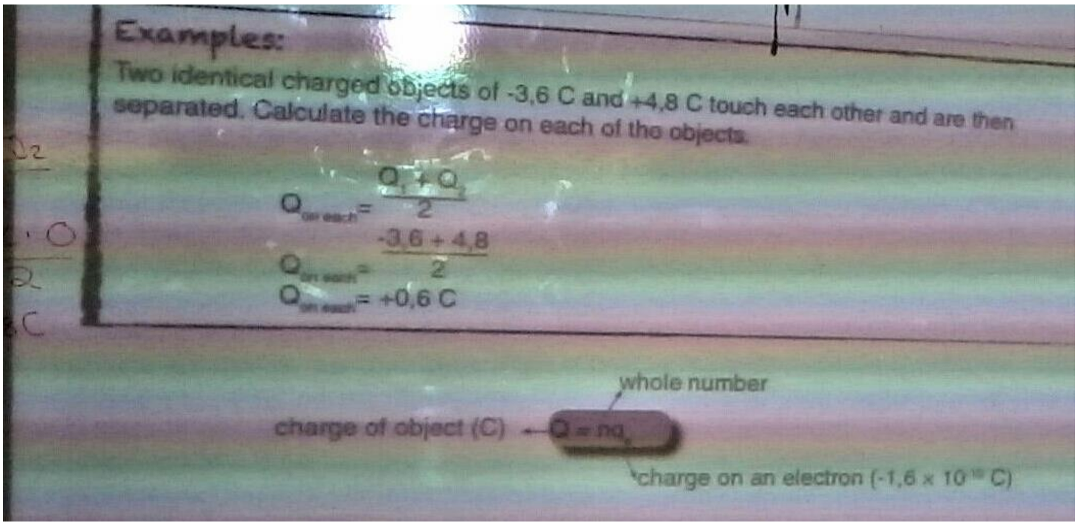


Figure 5-16: Martha's lecture presentation on problem-solving questions related to the law of Conservation of charge

5.8.2.1 Analysis according to observation schedule for lesson 2

Assessing learners' learning

Martha assessed learners' previous knowledge through a teacher-directed question and answer approach on the atom and its constituents. She also assessed learners' learning during the practical demonstration. This was observed when she gave one of the learners a metal rod to rub on his jersey and asked him to explain his observation. However, she did not correct a learner's wrong answer to the specific question asked in the lesson introduction.

Instructional delivery

Martha's lesson on electrostatics was presented to meet the planned objectives outlined in the Lesson Study plan. She used different teaching strategies to support learners' understanding of the lesson taught. Martha frequently emphasised important points that learners must know and their application to solving questions in the exam. She explained a few problem-solving tasks from her slide based on the planned activities. She clarified learners' perceived difficulties during her teaching, when she gave an elaborate explanation on charge distribution and solved examples on finding the magnitude of force between two charges. Martha also used simulation activities to enhance learners' understanding of the concept of static electricity on balloons, charge transfer and charging by induction.

Classroom interaction

Martha ensured that key terminologies used in her teaching were well defined and projected on her PowerPoint slides for learners' view. She actively encouraged learners to participate in the teaching process by using the question and answer method. She also supported her learners' learning by providing corrective feedback to most of the learners' wrong answers. Martha's use of simulation models enabled her to create an environment of interest for learners' interaction with the lesson. She had a good interaction relationship with her learners which helped her to effectively manage the classroom. Learners were well behaved and attentive during the teaching. Though she did not make use of small group activities during her teaching, independent activities were given to learners in the form of homework.

Teachers' knowledge

Martha demonstrated her teaching knowledge when she emphasised key concepts that learners needed to know for the exam. She focused on clarifying learners' difficulties in the topic using her marking experience. She demonstrated her pedagogical knowledge by using various teaching strategies such as explanation, simulations, practical demonstration and problem solving to teach the lesson. However, she occasionally made mistakes in explaining some concepts and she did not provide corrective feedback on learners' response to constituents of an atom. This shows a gap in her own content knowledge. Martha showed empathy towards her learners when she asked learners to meet her after the lesson for extra coaching if they did not understand the topic. She did not give learners enough time to write down notes from her PowerPoint slides.

5.9 Third Lesson Study meeting by pair B

5.9.1 Second reflection session by pair B

The third Lesson Study meeting was held on a Thursday afternoon at Roderick High School. The meeting started with a word of appreciation from the researcher. The teachers watched the recorded video lessons for observation and reflective purposes. During the observation, Martha suggested that the meeting should be brief because they needed to prepare for learners' examination. Both teachers reflected on possible challenges that might affect the completion of the planned syllabus.

> ***Alex:*** *This week has been crazy with all the extra murals going but I am pushing to get all the work done because the exams are close and the next topic has a lot involved. So, I will just rush up whatever it is that needs to be done as fast as I can…….and I am still behind with the Grade 11's".*
>
> ***Martha:*** *The school has been busy with a lot of activities lately which is affecting my class periods and now I have just received a circular concerning the exam which keeps me thinking that I need to rush up my lessons with the learners. So, more focus needs to be on the electric circuit because that's where I see a problem for the learners.*

Martha reflected on the essential strengths of her lesson. She indicated that learners could see how electrons moved from one point to another point. Martha was confident that the simulation activity made the lesson real, visible and interesting to learners.

Alex mentioned helping learners to visualise the concept of charge transfer using an actual metal sphere as the essential strength of his lesson. Alex indicated that if he was to teach the lesson again, learners would practically demonstrate how to charge an electroscope by contact and induction. He also reflected on the success of his lesson. He indicated that the observed lesson was not successful. He said,

> **Alex:** *Seriously, I see that learners are still struggling with how to use the correct formula for a charge on a single object and how many electrons for when the charge is separated. I think this is because I used just one example*

on the board so I hope to go through more exercises using a couple of questions if time permits to help them know when to use which formula. Then I will say the lesson is successful.

From his response, it seems Alex believes that learners' understanding of mathematical concepts and procedures will improve their knowledge about the correct formula to use. This could imply that Alex assumes that learners' use of correct formulas determine the success of the lesson. The teachers were encouraged to take note of important points discussed during their reflection to incorporate into their practice for improvement purposes.

5.9.2 Third planning session by pair B

The third lesson planning was on electric circuits. Teachers discussed learning goals and assessments to be used in the lesson. They indicated that learners must know the meaning of emf, potential difference, current and resistance; measurement of voltage and current; and be able to solve questions on resistance in series and parallel. The curriculum requires that learners do a compulsory portfolio practical on the electric circuit. The teachers discussed the lesson based on structured content, concepts and skills outlined in the CAPS document. Martha wrote the lesson plan using a soft copy of the provided template. Alex wrote the mind map of what the lesson involved as shown in Figure 5.17.

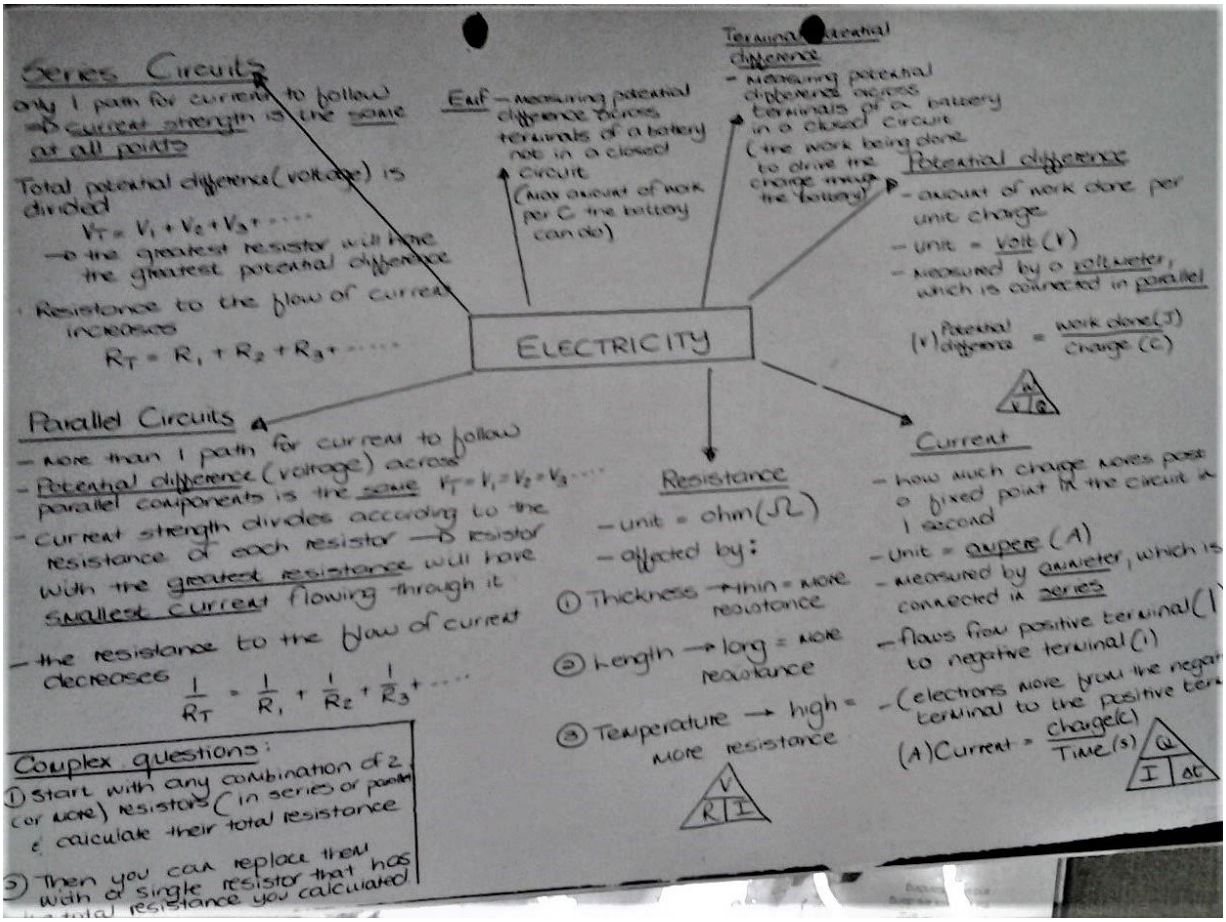
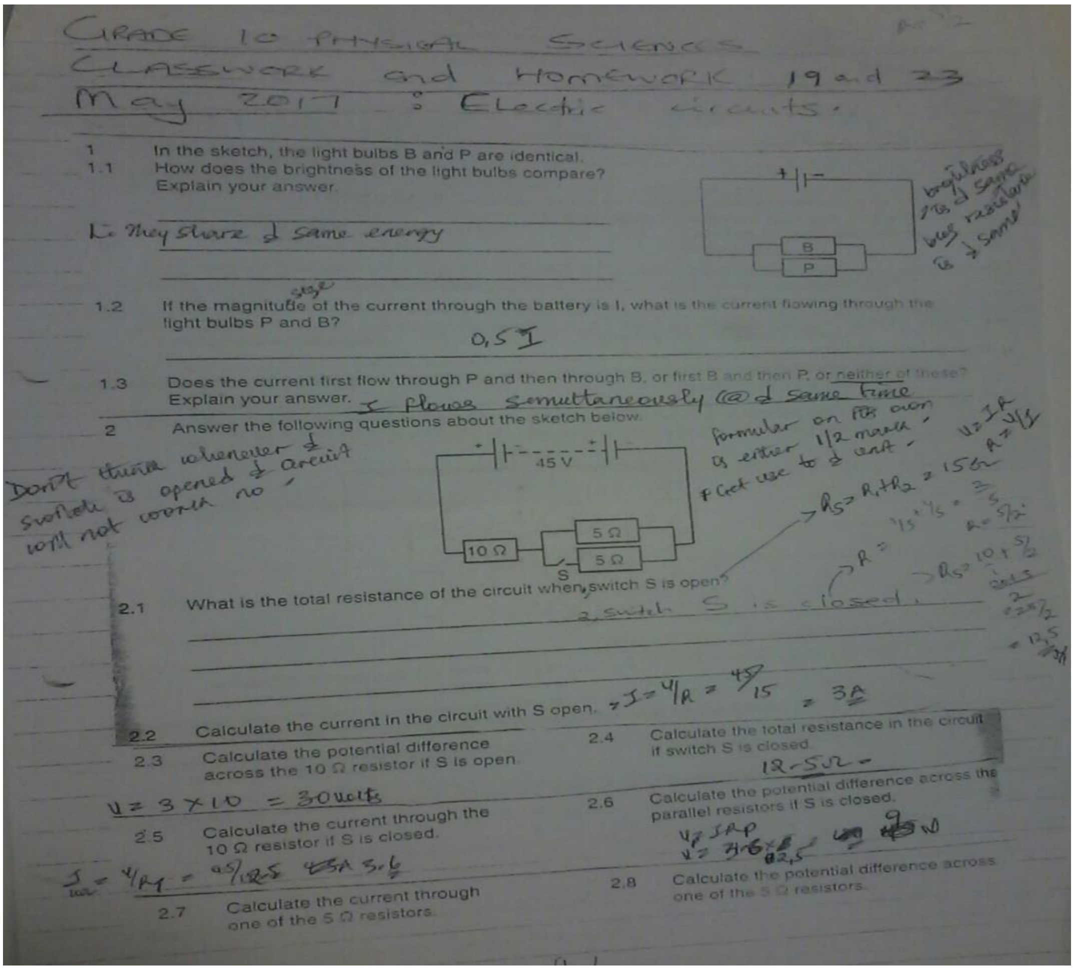


Figure 5-17: Lesson Study pair B's mind map on the electric circuit

As the meeting continued, teachers shared their experiences on learners' difficulties in the electric circuit. They indicated that most learners have difficulties in solving questions involving parallel and complex circuits, and they are unable to differentiate between emf and potential difference. Teachers discussed how the Ohm's law triangle and independent mathematical equations, for example, $R_T = (R_1 \times R_2) / (R_1 + R_2)$ can be used as techniques for solving problems on complex and parallel circuits respectively. The teachers jointly solved a few questions on resistance in a circuit. However, the researcher observed that these examples were insignificant to learners' classroom challenges, since it focused on series calculations. As deliberations on problem-solving questions continued, Alex gave a photocopied extract from a textbook with a few questions that were also considered and solved as examples of classwork and homework to be given to learners to the researcher and Martha, as shown in Figure 5.18,



GRADE 10 PHYSICAL SCIENCES
CLASSWORK and HOMEWORK 19 and 23
May 2017 : Electric circuits.

1 In the sketch, the light bulbs B and P are identical.
1.1 How does the brightness of the light bulbs compare? Explain your answer.

1.2 If the magnitude of the current through the battery is I, what is the current flowing through the light bulbs P and B?

0,5 I

1.3 Does the current first flow through P and then through B, or first B and then P, or neither of these? Explain your answer.

2 Answer the following questions about the sketch below.

2.1 What is the total resistance of the circuit when switch S is open?

2.2 Calculate the current in the circuit with S open.

2.3 Calculate the potential difference across the 10 Ω resistor if S is open.

2.4 Calculate the total resistance in the circuit if switch S is closed.

2.5 Calculate the current through the 10 Ω resistor if S is closed.

2.6 Calculate the potential difference across the parallel resistors if S is closed.

2.7 Calculate the current through one of the 5 Ω resistors.

2.8 Calculate the potential difference across one of the 5 Ω resistors.

Figure 5-18: Lesson Study pair B's problem-solving examples for classwork and homework on electric circuits.

The teachers agreed to incorporate pictures, videos and animations into their teaching so that learners could have a better understanding of the lesson. Finally, the meeting concluded as the teachers resolved to use what works best for their learners since they understood d their learners' characteristics better.

5.10 Classroom observation for the third research lesson

5.10.1 Alex's third lesson presentation

Alex's lesson presentation on the electric circuit was conducted on the 19th of May between 11:20 am and 12:40 p.m. He started his lesson by providing feedback on learners' homework from the previous lesson. Learners marked their homework as the teacher wrote the answers on the board. Soon after the feedback, Alex introduced the lesson to learners using a PowerPoint presentation about the definition of potential difference, current, and resistors together with their units, symbols, formulae and diagram. He read and explained notes from the slides to learners. Learners were given the opportunity to write the notes in their books. Next, he used the following questions to explain the concepts presented on the slide.

1. What is the potential difference across a light bulb that needs 120J of energy to move 20C through the light bulb?

   V=W/Q
   = 120/20
   = 6 J/C or 6 volts

2. How much current is flowing when 10C of charges moves past a point in 5s?

   I= Q/Δt

   = 10/5

   = 2 $C.S^{-1}$ or 2A

As the teaching continued, Alex used verbal questions to assess learners' understanding of how work is done through kinetic energy and potential energy. Next, he explained how resistors convert electrical potential energy into other forms of energy and how electrons transfer kinetic energy to the particles causing the material of the resistor to heat up. Later, he introduced the concept of resistors in series and parallel using different diagrams and examples to enhance learners' understanding of how resistors can be added in series and parallel. A picture of one of his slide presentations on addition of resistors in parallel is provided in Figure 5.19.

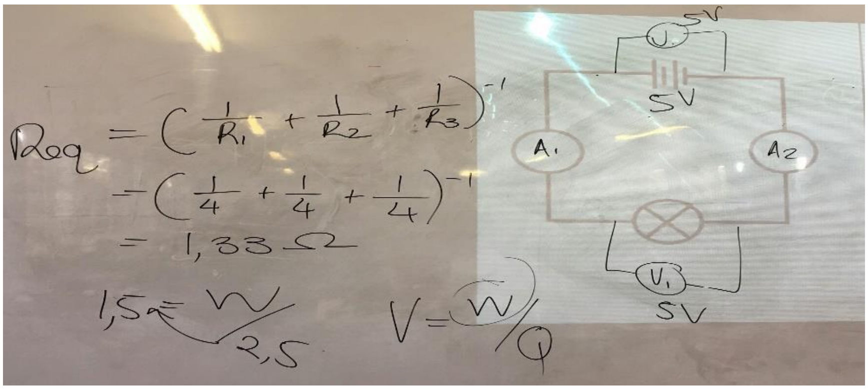


Figure 5-19: Alex's PowerPoint explanation on addition of resistors in parallel

Soon after he had finished explaining notes on resistors from the slides, he distributed a photocopied paper to all the learners and switched off the projector. He continued his teaching by explaining notes from the photocopied material. He explained the concept of lost volts as the energy used to drive the charges through the battery only and he described electromotive force as the maximum possible energy a battery can supply to the circuit ($E = V_{ex} + V_{lost}$). Next, he introduced the concept of Ohm's law to the learners by explaining the relationship between voltage, current and resistance in an electrical circuit. He emphasised that learners must know how to apply the law when solving questions on combined circuits. A sample of Alex' solved example on the application of Ohm's law in a complex circuit is shown in Figure 5.20.

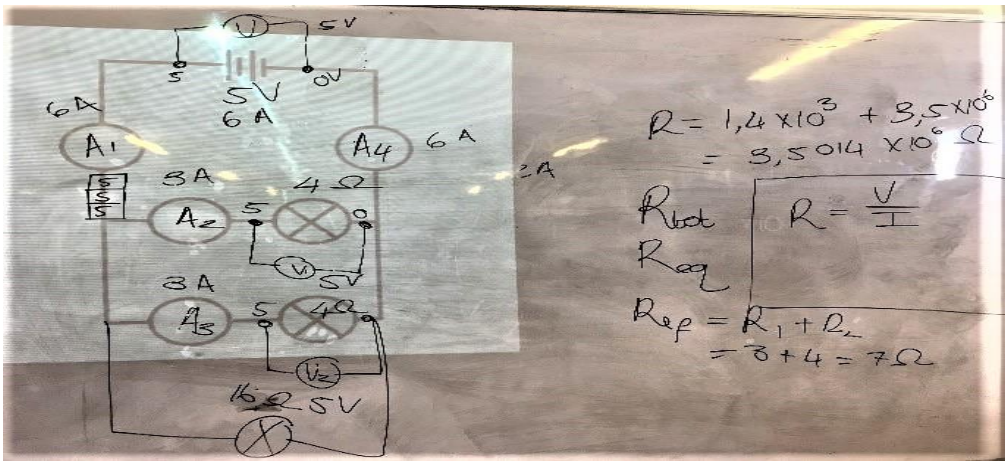
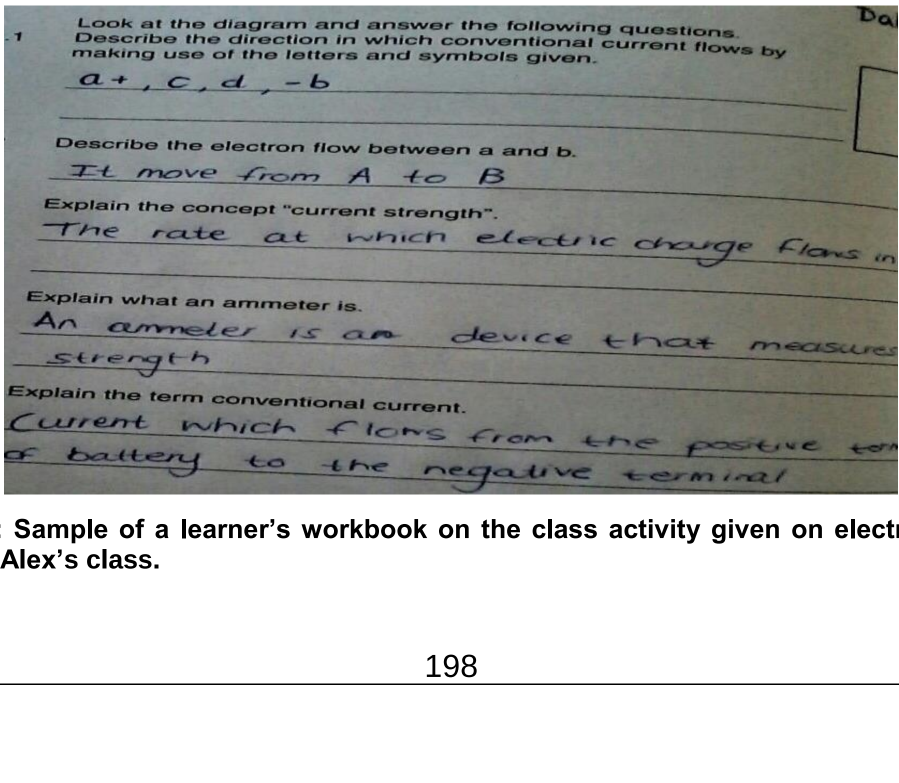


Figure 5-20: Alex's worked examples on Ohm's law using a combined circuit

Learners were given the opportunity to write the solved examples in their notes, and thereafter answer questions from their workbook as a class activity. Alex went through the class to assess individual learners' work. Learners were required to exchange their books for marking as the teacher provided corrective feedback on the class activity. A sample of one of the learners' class activity is shown in Figure 5.21.



Look at the diagram and answer the following questions.

.1 Describe the direction in which conventional current flows by making use of the letters and symbols given.

a+, c, d, -b

Describe the electron flow between a and b.

It move from A to B

Explain the concept "current strength".

The rate at which electric charge flows in

Explain what an ammeter is.

An ammeter is an device that measures strength

Explain the term conventional current.

Current which flows from the positive ter of battery to the negative terminal

Figure 5-21: Sample of a learner's workbook on the class activity given on electric circuit in Alex's class.

Learners were asked to attempt another exercise from their workbook as homework. Next, Alex grouped the learners for their portfolio practical assessment. Learners were required to demonstrate and explain what happens when a battery and two light bulbs were connected in series and parallel respectively. Alex assisted each group in setting up the circuit and explained how to take their readings. The bell rang and the teacher informed learners to keep all resource materials used during practical to enable them to finish up their report writing in the next class. A picture of learners performing their practical experiment on the electric circuit is shown in Figure 5.22.

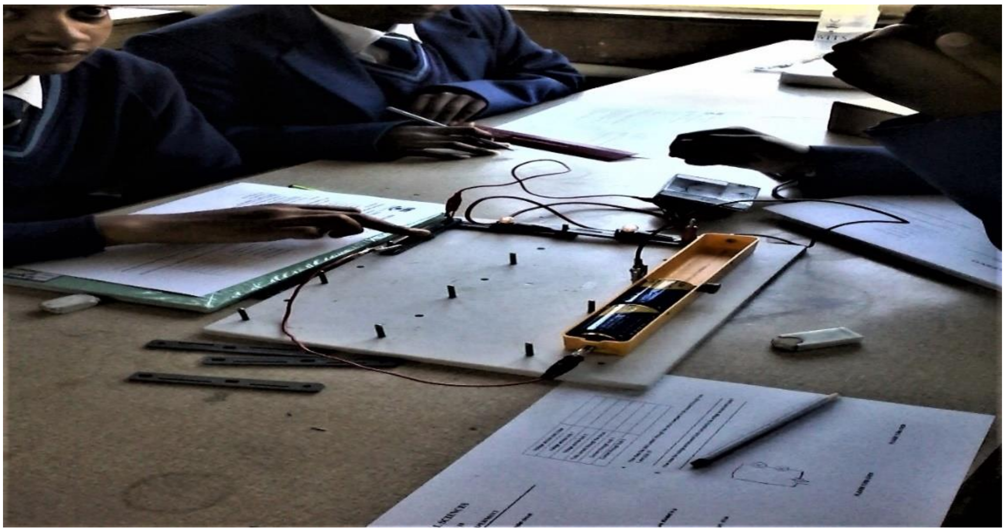


Figure 5-22: Group of learners in Alex's class performing a practical experiment on an electric circuit

5.10.1.1 Analysis according to observation schedule for lesson 3

Assessing learners learning

He assessed learners' previous knowledge using the teacher directed question and answer approach. This was observed when he asked learners for the two basic forms of energy, components of a cell and energy conversion by chemicals in electric cells. He also assessed learners' understanding of the lesson taught when he gave them class activities from their workbook. He clarified difficult concepts that individual learners encountered during the class activity since he walked around the class to check for their understanding. Learners' understanding of the lesson was also assessed during the practical demonstration. This was observed when Alex asked questions about the uses of basic electric components before assisting the learners with their circuit connections.

Instructional delivery

Alex's teaching was presented to meet the planned objectives outlined in the Lesson Study planning template and CAPS document. He used various teaching strategies such as demonstration, illustration, direct teaching and computer-based instruction to enhance learners' conceptual understanding of the electric circuit. Alex did not integrate examples from the real world into his teaching. His lesson was taught based on theoretical and scientific terms. Unfortunately, no practical application of the lesson for learners' immediate environment was indicated. Alex also used relevant activities focused on calculations to clarify important concepts and enhance learners' problem-solving skills. He laid emphasis on important points that learners must know for exam purposes. Alex supported his learners' learning and lesson delivery by integrating a multimedia presentation into his teaching. This also helped him to effectively manage the learners' disruptive behaviour as they were attentive during the teaching process.

Classroom interaction

The teacher-learner relationship in Alex's classroom was well enhanced and effectively managed all through this lesson. He encouraged and facilitated good interaction among learners using the question and answer approach. He used various teaching strategies such as direct instruction, demonstration, and practical experiment to promote learners' understanding of the lesson content. This was observed when he wrote out key definitions and formulae needed in the topic on the board using learners' response to questions asked. There was a cordial communication process between Alex and his learners. He related well with learners by adequately responding to their questions without hesitation. Alex encouraged group activities among his learners in the form of a practical experiment and encouraged independent work by giving homework as planned during the Lesson Study planning session. Alex maintained effective eye contact with his learners during the teaching process, this helped him to effectively manage the tone of his voice.

Teachers' knowledge

Alex ensured that the content of the lesson was well presented to meet the learners' needs as required by the CAPS document. He demonstrated adequate and effective knowledge of the topic taught by explaining key concepts without reading from textbooks or slides. This showed that he was confident about his knowledge. This was also observed during the practical activities when he guided the learners on how to correctly connect a circuit. Alex checked for learners' understanding of the topic during the practical activities. This showed that he was committed and enthusiastic about his learners' understanding of the topic. Alex also showed empathy towards learners' inability to understand the lesson. This was observed when he illustrated how learners could know if their connection was right or wrong during the practical activity by tracing the path of the current with their finger through the circuit. He also emphasised that an ammeter is always connected in series and a voltmeter is always connected across the circuit in parallel. Alex did not mark learners' class activities, but he provided learners with accurate feedback on their class activity.

5.10.2 Martha's third lesson presentation

Martha's lesson on the electric circuit was presented on the 23rd of May from 9:45 am to 10: 55 a. m. She used explanation and multimedia interaction as her teaching method. She started her teaching by informing learners about their examination timetable and scheduled dates for writing the subject. She also informed learners about the need to perform a practical cycle assessment on the electric circuit before the commencement of their exams. She used the question and answer method to revise learners' knowledge of electric circuit components. Martha instructed learners to go through their Grade 9 work on electric circuits to enable them have a better understanding of the topic. As the teaching continued, Martha asked: what the three important things required for any electrical circuit were. One of the learners replied "a battery". The teacher responded, "be careful, not only a battery". Then the learners echoed " cell, a source of energy" simultaneously. Martha corrected the learners by indicating that "it doesn't have to be a cell or battery but it must be a source of energy, a conductor and a closed circuit". She indicated that those three conditions must always be met. Martha specified that learners' knowledge of circuit components will be assessed in the examination, so learners had to know how to draw, explain the functions of basic circuit components and apply them in solving problems. She continued her teaching by describing the diagrams of various circuit components like conductors, resistors, cells, switches, variable resistors, voltmeters and ammeters. During her explanation, a learner asked: what the difference between a cell and a battery was. Martha replied, “A battery is more than one cell or we can say multiple cells create a battery”. Martha’s explanation was not clear. A cell is described as a single unit that converts chemical energy into electrical energy, while a battery is described as a group of cells. She used oral questions to assess learners understanding of the lesson, and later explained how learners could remember how to connect a voltmeter and an ammeter in a circuit. She said,

> *The two lines for letter V are separated from one another, which implies that a voltmeter is always placed over an object and the line across capital letter A indicates that an ammeter is placed closed to each other which implies that it is always connected in series. (Martha, interview).*

A picture of Martha explaining the connection of a voltmeter and an ammeter is shown Figure 5.23.

Figure 5-23: Martha explaining the diagram of components in a circuit to her learners

Martha used a teacher-guided question and answer method to explain the concept of resistors in series and parallel. During the explanation, one of the learners asked “ma, what is the meaning of negligible”, Martha responded by saying “it means so little that we assume its zero”. She presented and explained her slide on the definition, symbol, formula and unit for potential difference. She described potential difference as”the difference in the electrical potential energy between any two points in a circuit”. She explained a few problem-solving examples on potential difference from her slide and emphasised the following points during her teaching.

> *Learners must know that the unit Volt and J/C (joules per coulomb) is the same thing, remember the first mark is for writing down your formula, the second mark is substituting in that formula and lastly no unit no mark. (Martha, interview).*

Learners were given the opportunity to write down the displayed examples on potential difference in their notebook. As the teaching progressed, she indicated that the potential difference in a series circuit will always sum up to the potential difference given by the energy source. During her explanation she said, “If this battery has a potential difference of three volts, then the voltage in V_1 plus the voltage in V_2 must be equal to the total voltage given by the source which is V_T’ i.e. $V_T = V_1 + V_2$, where V_T is the same as $V_{across\ battery}$ which is three voltsin this diagram”. Next, she explained the potential difference across a parallel circuit to be the same as the potential difference across each resistor i.e. $V_P = V_1 = V_2$. Learners were asked to attempt an exercise in their workbook as homework. As the teaching continued, Martha indicated that learners would not be able to perform the practical experiment for their cycle test as mentioned earlier, but they will be given values to work with for their practical cycle.

During the next period, Martha provided corrective feedback to learners’ homework and revised the concept of potential difference in circuits. She presented and explained her next slide on formula, unit, symbol and measurement for current strength as shown in Figure 5.24. She explained that the value for current in a series circuit remains the same i.e. $A_1 = A_2 = A_3$ while the current in a parallel circuit is divided across each resistor i.e. $A_1 = A_4 = A_2 + A_3$. This implies that the sum of currents across each resistor in a parallel circuit equals to the total current provided by the battery.

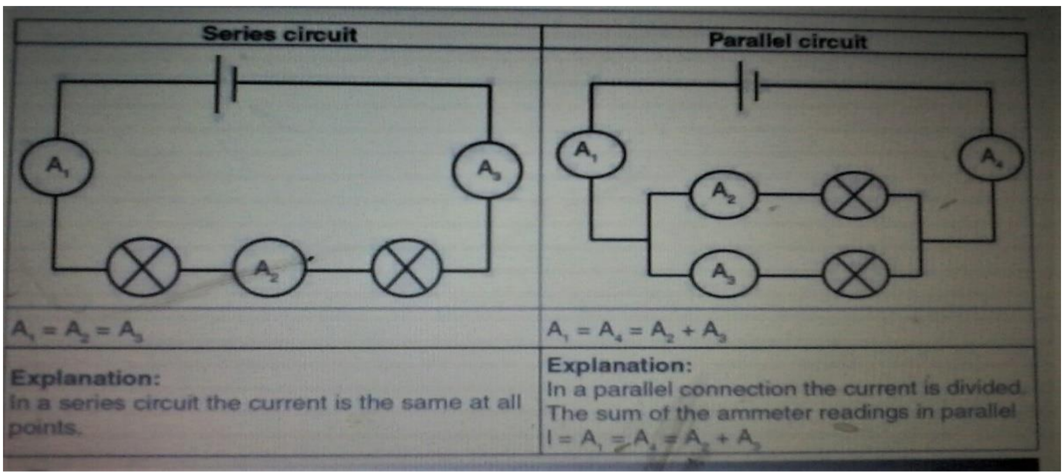
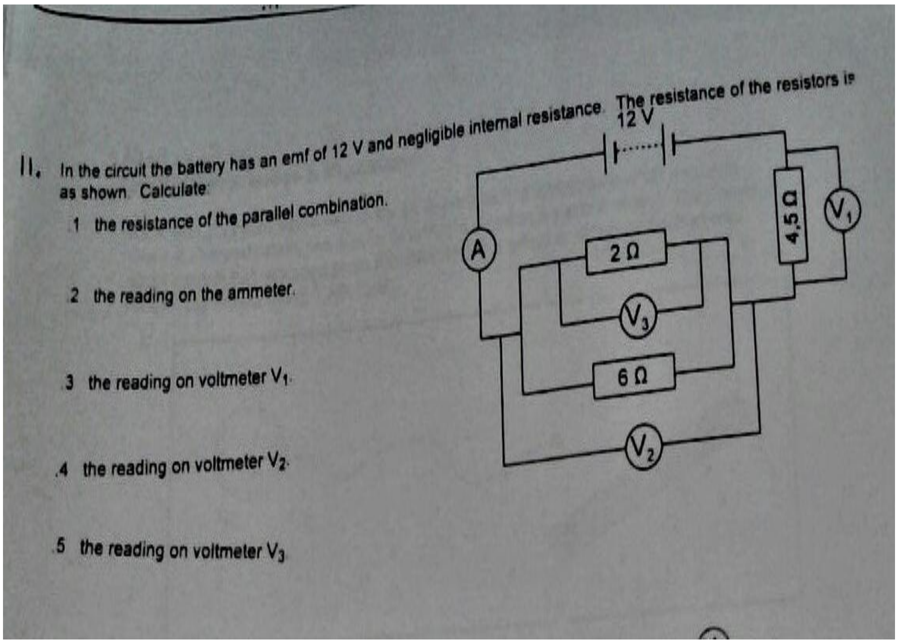


Figure 5-24: Martha’s lesson presentation on current in a circuit.

Learners were asked to define resistors and they responded by saying “resistors resist the flow of current”. Martha explained that resistance and resistors are the same. She mentioned temperature and thickness of a conductor as factors affecting the resistance of an object. She explained the total resistance of a series circuit as the sum of the individual resistances ($R_{total} = R_1 + R_2 + R_3$), and the total resistance in a parallel circuit as the sum of the inverses of each resistor in parallel ($1/R_{total} = 1/R_1 + 1/R_2 + 1/R_3$). Martha described the relationship between current, potential difference and resistance using Ohm’s law. She wrote the formula ($R = V/I$) on the board and explained the law as she read notes from her slides. She explained a few worked examples and distributed a photocopied paper as shown in Figure 5-25 to the learners. Learners were instructed to write the following additional questions in the photocopied paper they were given.

- Explain what happens to the potential difference supplied by the battery
- What is the mathematical relationship between the readings on your V_1, V_2 and V_3?
- What application of this do we use in our homes?
- State your conclusion for the voltmeter reading.

Learners were given the opportunity to use their textbooks in answering the question.



11. In the circuit the battery has an emf of 12 V and negligible internal resistance. The resistance of the resistors is as shown. Calculate:

1 the resistance of the parallel combination.

2 the reading on the ammeter.

3 the reading on voltmeter V_1.

4 the reading on voltmeter V_2.

5 the reading on voltmeter V_3

Figure 5-25: Alternative to practical instructions given to learners in Martha’s class

The classroom was quiet as learners independently completed reports about the practical which they were supposed to do. Martha asked learners to submit their completed report to her table before the next morning. The practical activity was not conducted as planned in the Lesson Study planning session and it was not aligned to the proposed portfolio practical in the CAPS document. A picture of learners working on their portfolio practical test is shown in Figure 5.26.

Figure 5-26: Learners in Martha's class answering the alternative to practical activity on the electric circuit.

5.10.2.1 Analysis according to observation schedule for lesson 3

Assessing learners learning

Martha assessed her learners' previous knowledge on electricity by asking questions related to Grade 9 lessons. This was observed when she asked learners to identify the components of a circuit. She checked for learners understanding of the lesson by asking questions on concepts taught. For instance, she asked the learners if a circuit could run without a switch and they all echoed "yes". She also assessed learners' understanding by giving them class activities and homework.

Instructional delivery

Martha's lesson on the electric circuit was theoretically presented to meet planned objectives, but not in terms of planned practical activities. She captured her learners' attention and interest in the lesson by using a PowerPoint presentation. She clarified learners' misconceptions in the lesson. This was observed when she explained to learners that a circuit cannot run when the switch is opened. She also used a few examples on problem-solving questions to clarify learners' mathematical knowledge. She emphasised main points that learners must know in preparation for their examination.

Classroom interaction

Martha used various lecturing activities such as re-teaching, lecture presentation and visual aids to enhance learners' conceptual understanding of the lesson taught. She enhanced her lesson delivery using multimedia presentation. This also created an opportunity for her to capture learners' interest in the topic. She encouraged learners' participation in the teaching and learning process using teacher-directed question and answer approach. This was observed when she encouraged learners to explain what happened to the current and voltage in a series and parallel circuit. She later presented the answers on the board using a tabular representation. She was expected to engage learners in a practical experiment during the lesson but no group or paired practical experiment was conducted. However, she encouraged independent work among learners by giving them class activities and homework. Learners were silent throughout the teacher's explanation which could imply that the classroom environment was conducive to learning. However, the researcher observed that most of the learners were reading from their textbooks during the teacher's explanation. This could be an indication that they were not learning.

Teachers' knowledge

Martha demonstrated her subject matter knowledge when she explained key terms like current strength, potential difference and resistance to enhance learners' understanding of circuit connections. It is not clear whether she has the practical knowledge required in teaching the topic since she did not perform the planned practical experiment with her learners. Martha displayed commitment and enthusiasm about the lesson by checking for her learners' understanding of the topic taught. She demonstrated her professionalism by providing corrective feedback on learners' homework even though she did not mark the homework.

5.11 Lesson Study pair B's reflection on research lesson 3

During the final phase of the Lesson Study intervention, the teachers could not meet as planned since they were preparing for learners' examination. Their reflection on research lesson three was conducted in their respective schools. The teachers' reflective writings presented during the study is also discussed in this section.

5.11.1 Alex's verbal reflection

The reflection session on Alex's third lesson presentation took place on the 1st of June. Alex reflected on the main strength of his lesson when he said:

> *Hmmm, the electric circuit I think how I did it on the board is quite effective, you know showing them you know when this current split and why. Why does voltage remain or changes in both parallel and series circuit? Making them think of coulombs as charges as little boxes where one box goes to one branch and another box goes to another branch, and using it to explain how current moves in a parallel circuit. So, you know I think showing them that was quite effective. (Alex, interview).*

Alex's response revealed that he used a simple analogy to enhance learners' understanding of how current splits in a parallel circuit. It seems that Alex initially believed that learners are already familiar with the daily application of electric circuits in their environment. So, he did not use daily life experience to stimulate learners' interest from the beginning of the lesson. However, he indicated that if he was to teach the lesson again, he would do more on explaining things like how electronics work and possibly incorporate the use of daily life experiences into his other lessons. He also reflected on how learners' outcome could be achieved from the beginning of the lesson. He suggested the use of various teaching strategies like having a ten to fifteen minutes short test after every class, forcing learners to study, involving learners in more hands-on experience practical activity and solving more examples. He reflected on his learners' challenges after attending the lesson and suggested other strategies that he could use to enhance their understanding of the lesson.

> *I see that some of the learners are still struggling with Ohm's law when I asked them what is the current through a bulb and the voltage across the same bulb. It gets confusing to them so I see that I must do more exercises for them. They*

> *also struggled with scientific language when writing their practical so I will try to make sure that I help them out by rephrasing their ideas in scientific terms until they can perfect that. I will also emphasise on the scientific terms that are needed when explaining anything and give them feedback on how they are expected to respond.(Alex, interview).*

Alex was also concerned about his learners' attitude during the practical experiment. Learners relied more on the teacher's assistance in connecting the circuit instead of them connecting it on their own. He reflected on how to improve learners' practical knowledge.

> *I will let the learners have a period in which they can play around with the circuits and set them up as they like so that they may become familiar with the apparatus before they do a formal experiment. I will make sure I use a physical circuit board just like the one used during the practical in future to show them how to set up ammeters and voltmeters when teaching that section, instead of using circuit diagrams on the whiteboard.(Alex, interview).*

It seems that participating in this study improved Alex's understanding of the importance creating continuous opportunities for learners to actively engage in practical activities to better enhance their conceptual understanding.

Alex's reflective writing

During the first Lesson study meeting, Alex agreed to write the lesson plan for lesson one using the Lesson Study plan template provided. When reflecting on his first research lesson, he indicated how he struggled when writing the lesson plan on research lesson one using the Lesson Study plan template I provided for this research. He indicated that he was used to simpler planning formats. His reflective writing reveals that his knowledge of lesson plan writing has increased, which is a representation of what he has learnt while participating in this study. During the observed lesson presentations, Alex did not use real-life examples in explaining his lesson. He believes that learners already know the basic concept required in the topic based on what happens in their environment. However, his writing indicated that the collaborative phase of Lesson Study gave him the opportunity to get involved in discussions that emphasised the importance of using real-life examples in stimulating learners' interest in a lesson. This implies that teacher collaboration during this Lesson Study intervention improved Alex's pedagogical knowledge and his understanding of how learners responded to questions. A screenshot of Alex's reflective writing retrieved from his mail is portrayed in Figure 5.27.

My reflection on what I have gained working with you on this study.

1. Discussions with you made me realize that I just teach my lessons direct based on theoretical scientific concepts without using some rea -life examples to capture the learners' interest in the lesson. I believe that discussing with you and the other teacher has helped me understand the importance of relating the theoretical aspect of the lesson to its application in daily life challenges and things around us which could be used to stimulate or capture learners interest in the subject and I believe that could make the teaching of the lesson more fun to learners as you mentioned.

2. I have seen and used different types of lesson plan but I happen to find the lesson plan template you gave to me a bit challenging because I had to struggle through the writing process especially when thinking about teacher's expectation from learners. It got me thinking all through and I learnt something new from the lesson plan which is when preparing for my lessons, I need to understand how my learners will respond to questions asked and therefore prepare my feedback to address whatever it is I already know they will say which could be right or wrong. It's like I should think like my learners.

Figure 5-27: Screenshot of Alex's reflective writing retrieved from mail

5.11.2 Martha's verbal reflection

Martha reflected on her lesson content which she believes was well delivered since she emphasised important points that learners needed to know in the topic. She expressed concern about using her lesson introduction to capture learners' interest in the lesson.

> *For circuit electricity, there is a simulation I would have used to capture learners interest but it's quite difficult because they know they will connect a voltmeter but unfortunately, they don't know what a voltmeter is. So, they need to understand the basics before I can do anything, and that is why I think learners get stuck on what to do. (Martha, interview).*

She also reflected on her learners' lack of understanding even after teaching the topic, which implied that her lesson objective was not met. She suggested alternative strategies that could be used in helping learners understand some concepts better, to enable her to achieve her lesson objective.

> *I have experienced that especially with the combination circuit where I have series and parallel together they still get stuck on what to do… Eeem… that I will probably say; yesterday I had a remedial class and I found out that there is one learner that thinks potential difference and current is the same thing. So, I observe that you will always see those set type of learners that sit through all the lessons after every period and they still miss it somehow somewhere. Eeem that makes it quite difficult so for that learner I will probably try and give him additional activities, extra classes if he shows up. (Martha, interview).*

Martha is concerned about her learners' negative attitude towards learning. She believes that these attitudes also affect learners' understanding of the lesson.

> *Eeem I organize remedial classes; I give homework but unfortunately not all the learners come for my remedial class nor do the homework but I will probably need to have another remedial class again on circuit electricity basically before their exams. .(Martha, interview).*

Martha reflected on the importance of the lesson content to learners' knowledge application in their immediate environment. She believes that most learners don't realise the relevance of most science lessons until later.

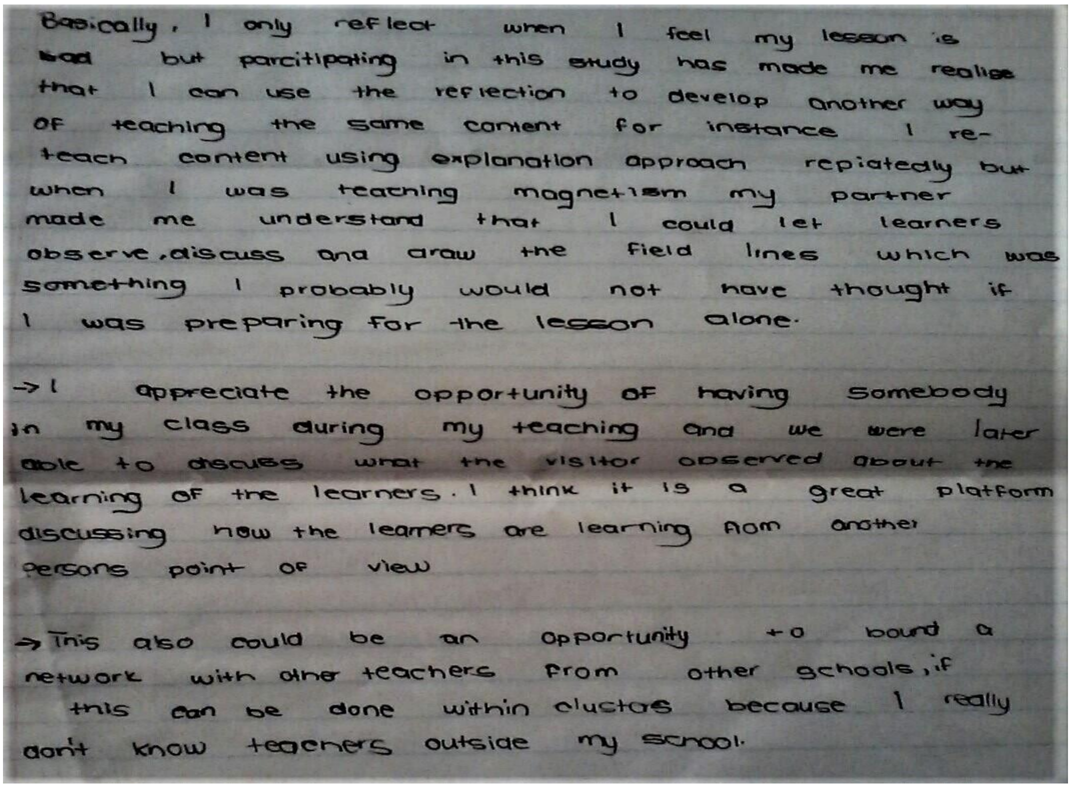
> *I think at this stage they just try to understand the concept and don't realise how important it is to their everyday life but on something simple like light bulbs, like not to overcharge or Eeem put in too many plugs on a plug source and why. I think that aspect is very important and especially Eeem the problem we have in South Africa with the stealing of this electricity from one house to the other that you are overtiring the circuit. So, I think that might help them challenge those activities later. But I think at the Grade 10 they don't understand the importance of these lessons now because I found out with the Grade 11 learners I taught last year, the moment I went into details of these concepts then I heard them saying oh that's why this is dangerous, ooh that's why people get shocked. Then the lesson starts making a bit more sense to them so at Grade 10 they are just trying to memorize the work.*

She also reflected on how to improve her teaching on the electric circuit. However, she avoids the issue of practical work.

> *If I am to change anything in my lesson I think I would like to know how better to teach current electricity. I understand it but it is very difficult for me to explain it to them differently so but exactly how I don't know. Maybe I will give them more tables, show them more pictures and explain more about how it works and all that I don't know. I think I will still have to go and do more research and reading since this Lesson Study encourages reading several kinds of literature about a concept to be addressed I believe I learnt that and I will try to do it. (Martha, interview).*

Martha's reflective writing

During the initial interview with Martha, she indicated that she did not engage in collaborative activities with teachers outside her school. This study gave her the opportunity to work with another teacher from another school. Prior to this study, Martha reflected on her learners' difficulties based on her feelings about a lesson and re-explain such a lesson. The lesson observation phase and brainstorming session of this study increased Martha's awareness on other methods of using reflection to enhance learners' understanding of the difficult topic. This was observed during the first Lesson Study meeting when she indicated that interacting with Alex has :*made her understand that she could let learners observe, discuss and draw the field lines which was something she probably would not have thought of if she was preparing for the lesson alone*." This implies that Martha's knowledge on how to enhance learners' visualisation and understanding of magnetic field lines has increased. It also created an opportunity for her to share information about her learners' learning from a different perspective. The researcher considers her reflective writing to be focused on learners' learning. However, during the third lesson it was observed that Martha did not give learners the opportunity to engage in practical activity as planned during the Lesson Study session and as required for their portfolio practical in the CAPS document. It is possible that the third lesson was not focused on learners' learning but on completing the syllabus. A picture of Martha's reflective writing is portrayed in Figure 5.28.



Basically, I only reflect when I feel my lesson is bad but parcitipating in this study has made me realise that I can use the reflection to develop another way of teaching the same content for instance I re-teach content using explanation approach repiatedly but when I was teaching magnetism my partner made me understand that I could let learners observe, discuss and draw the field lines which was something I probably would not have thought if I was preparing for the lesson alone.

-> I appreciate the opportunity of having somebody in my class during my teaching and we were later able to discuss what the visitor observed about the learning of the learners. I think it is a great platform discussing how the learners are learning from another persons point of view

-> This also could be an opportunity to bound a network with other teachers from other schools, if this can be done within clustors because I really don't know teachers outside my school.

Figure 5-28: Martha's reflective writing

5.12 Presentation and analysis of final interview

The final interview was conducted to explore the teachers' views on the effect of Lesson Study on their knowledge and practice. The obtained data is presented according to emergent codes generated from the teachers' responses and later categorised into the a priori themes addressing the research question. Details of a priori themes used in this study have been provided in Section 4.13 of this research work. An overview of the emergent codes, sub-themes and corresponding themes created during Lesson Study pair B's final interview is presented in Table 5.4.

Table 5-4: Overview of codes, sub-themes, and themes created during the final interview with Lesson Study pair B.

Codes	Sub-themes	Themes
Interesting model Teachers work together Find better ways of teaching Focus on learners' learning	Description of Lesson Study	Lesson Study experience
Teacher learning Collaboration	Advantages of Lesson Study	

Requires Commitment Complicated process Time-consuming Requires hard work Teacher’s beliefs about writing lesson plan Requires thinking Teacher’s belief about writing lesson plan	Challenges of Lesson Study	
Teacher’s perception of Lesson Study Teacher’s perception of science	Teachers’ belief	
Teaching strategies Lesson organisation	Pedagogical practice involved	
Discussing together Teacher’s belief First-hand practice Working with others	Teacher collaboration	
Knowledge of lesson plan writing Focus on improving learners’ learning Ability to recall what works best for learners Teaching Pedagogy	Teacher learning	
Look back on learners’ response and teaching methodology	Reflection	
Learners more attentive	Increased learners’ concentration	
Teacher’s belief, First-hand practise, Working with others, Discussing with somebody, Classroom observation, Working together to discuss learners’ problem, Building a professional network outside the school.	Collaboration	Teachers’ collaboration
Teachers work together Find better ways of teaching Focus on learners’ learning	Improved pedagogy	
Change in teacher’s belief about learners’ application knowledge. Improve teacher’s lesson introduction approach. A new approach to involving learners in practical. Demonstration on magnetic field lines.	Teacher learning	
Increase in learners’ concentration	Change in learners’ attitude	
Using lesson observation to identify how learners learn.	Form of evaluation	

Departmental support Teacher's interest Time organisation for professional development Improving teacher's professional development	Teachers' perception	Teachers' attitudes and beliefs
Using participative form of teaching Using critical reflection to develop new teaching methods Personal integration of knowledge	Teacher learning	
Teacher's interest Teacher's commitment	Teacher characteristics	Contextual factors and challenges
Support from the department Support from school principal	Support from stakeholders	
Many tasks involved in the profession.	Job responsibilities	
Teacher's responsibilities Teacher's interest	Teacher-related factor	
Support from school	School leadership	
Time	Resources	
Learners' difficulties Learners' attitude to extra classes	Learners related factors	
Classroom observation Limited time frame for school term Workload Don't have essential time for teaching	Challenges of Lesson Study	

5.12.1 Alex's Final Interview

The final interview with Alex took place on the first of June around 14:20 in the teachers' staffroom. The venue was not conducive to the interview due to the noisy movement of teachers in the staffroom.

5.12.1.1 Lesson Study experience

Alex described the Lesson Study process as "an interesting model" focused on how teachers can improve their teaching. He believes that working together to plan a research lesson, discuss teaching strategies that are appropriate for specific lessons and anticipating learners' outcome make the model quite valuable. During the interview, Alex reflected on the most important phase of the Lesson Study process.

> *The whole process is a valuable one and significantly important. One phase serves as a building block for the other so I don't think to separate any will be effective. You know I have attended few collaboration activities but time has not*

permitted me to practise what I have learnt. But this one gives you the opportunity to immediately practise what you learn or what you have done with others to see how effective it works for you in your capacity either in teaching or planning or something similar. So, that's it.(Alex, interview).

His response shows that he views the Lesson Study model as a systematic approach with several phases that are indispensable to teacher development. The next conversation occurred:

> ***Researcher:*** *What is the most challenging aspect of your Lesson Study experience?*
>
> ***Interviewee:*** *Being committed is a challenge because as teachers we have many responsibilities so time is a challenging factor Eeem…. writing the lesson plan especially when I needed to write my expectation from learners was quite challenging because at first, I did not know what to expect from the learners. These learners are unpredictable.*

Alex's response indicates that he also views the Lesson Study process as a complex and time-consuming process which requires commitment and hard work like every other teaching activity.

5.12.1.2 Teacher's collaboration

During the interview, Alex indicated that the different phases of the Lesson Study process is cycled into each other, this is ascribed as an iterative process that focuses on individuals working together to progressively solve problems. He said:

> *The whole process is a valuable one and significantly important. One phase serves as a building block for the other so I don't think separating any will be effective. You know I have attended few collaboration activities but time has not permitted me to practise what I have learnt. But this one gives you the opportunity to immediately practise what you learn or what you have done with others to see how effective it works for you in your capacity either in teaching or planning or something similar. So, that's it. (Alex, interview).*

Alex believes that working together in Lesson Study provides teachers with direction on how to identify, manage and improve their classroom practices. It seems that participating in this study gave Alex the opportunity to actively practice what he has learnt and receive feedback on his own classroom practice. However, further explanation on his experience reveals how working together in this study improved his knowledge. The impact of collaborating in this study on Alex's knowledge and teaching skills is discussed in the next section.

5.12.1.3 Teacher 's knowledge

During the Lesson Study meeting, Alex indicated how he struggled with writing the lesson plan using the provided template. However, his knowledge of lesson plan writing increased after working together with colleagues in this study (see Section 5.11.1.1). During his reflection on how the collaborative phase of Lesson Study influenced his professional knowledge and practice, he said:

> *In this regard, I always believe that learners have an idea of how science relates to them in their environment so I never really took my time to relate my lesson to things in the learners' immediate environment. So, I think I realised this when you asked me a question about the introducing my lessons using life challenges. So, this is one part I realised I need to improve on and that is because you pointed it out that it was not observed in any of my lessons. So yea, relating to you (researcher) made me realise the significance of letting learners know that for instance circuit is everywhere on our phones, television, sound system and all that.*

It seems that collaborative phase of Lesson Study gave Alex the opportunity to improve on how to make his learners feel engaged and interested in a lesson. This could be ascribed as the effect of collaboration on his pedagogical knowledge and practice.

5.12.1.4 Teacher's attitudes and beliefs

Based on the lesson observations, it seems Alex has an attitude of not incorporating real life situations into his lessons. He used to teach the scientific and theoretical content of science but does not relate it to real life applications in learners' environment. After participating in this study, Alex became more aware of the importance of integrating real life situations into his teachings (see Section 5.11.1). This implies that the brainstorming session of this study improved Alex's awareness about his teaching attitude. During the interview, Alex reflected on how participating in Lesson Study influenced his teaching practice. He said,

> ***I** don't know if this is part of the programme but I think your presence in the class made the learners attentive and respond well to my question. So, I think having an outsider in the class could sometimes create a good environment for learners to want to show that they know what they are doing but believe me not all learners would love that anyway. (Smiling) on the other hand, during your discussion on what you observed in the class, I realised that having class observations like this could sometimes help teachers to identify the gaps between learners' understanding of a lesson and teacher's method of teaching the lesson. You know I can be teaching a lesson but the way learners understand the lesson could be wrong or right so having an outsider observe how learners learn could sometimes help teachers to identify learners' reaction during the teaching because I believe as a teacher I can only see what I want to see and not the whole thing happening in my class.*

Alex's response reveals that the lesson observation phase of Lesson Study had a positive impact on his attitude and perception towards learners' concentration problem. This implies that the Lesson Study observation phases improved Alex's understanding of learners' characteristics.

5.12.1.5 Contextual factors and challenges

During Alex's reflection on Lesson Study experience, he indicated that Lesson Study is a time-consuming process that requires commitment and hard work. He believes that the use of Lesson Study as a teaching methodology among teachers depends on the teachers' interest, willingness and commitment. It seems Alex is also concerned about lack of support received from respective education authorities. He said:

> *First, an idea like this should be made known and facilitated by the department. Personally, I think I will still love to do something like this probably with teachers in my school if the principal approves of it and if the other teachers in science field are willing to because teachers are not willing for anything these days due to the many tasks involved in this profession.(Alex, interview)*

Alex was asked if there are any factors that might possibly affect his continuous use or practice of Lesson Study as a teacher. He replied:

> *Practically the only constraining factor I see here is time. Teachers are always busy and we have a lot of things to cover within a limited amount of time. So, that alone is a problem. Although I think there are other factors too which could probably surface along the line.(Alex, interview).*

Alex's clarification of likely factors that could surface along the line reveals that lack of financial budget from the school could also hinder teacher's continuous Lesson Study practice.

In summary, Alex's reflection on contextual factors reveals that time, teacher's interest, job responsibilities, commitment, willingness, time and support from respective stakeholders are possible factors that possess threats to teachers' effective and continuous participation in professional development programs like Lesson Study.

5.12.2 Martha's Final Interview

The final interview with Martha occurred in the physical sciences laboratory. The interview was conducted on the fifth of June, between 14:05- 14:55. The physical sciences laboratory was calm and conducive for the purpose of the interview.

5.12.2.1 Lesson Study experience

Martha believes that Lesson Study helps teachers to work together to find better ways of teaching difficult concepts. She indicated that having a visitor observe her lesson and discussing learners learning was the valuable phase of the study. In her words, she said:

> *"The point where you asked me to look back at what happened in my class in terms of learners' response to questions and the methods I used and all that was something I really valued."*

This implies that Martha's Lesson Study experience improved her reflection level. During the interview, she indicated that writing a lesson plan using the Lesson Study plan template was a unique experience for her since she does not write a lesson plan. According to Martha, she uses a prepared lesson plan provided by her HOD. Martha views lesson plan writing as a difficult task that requires intellectual thinking and consumes time. It seems that taking time to write the Lesson Study lesson plan was an interesting and challenging experience for Martha. This was observed when asked to describe the most interesting phase of her Lesson Study experience. She said:

> *I said earlier that the lesson plan writing was the most interesting part of your research work to me. However, let me say I realised that the focus of all what we were doing was looking for ways on how to prepare these learners for the world out there because as a teacher I believe that science is everywhere. I find it interesting because for every lesson plan I wrote I kept having it at the back of mind that learners must be able to do things on their own and indirectly work with one another.(Martha, interview).*

5.12.2.2 Teachers' collaboration

Martha indicated that the collaboration aspect of Lesson Study gave her a great opportunity to work with another teacher teaching the same grade level within her cluster. She also valued the opportunity given to her to think deep and discuss her learners's learning with a visitor. This was mentioned during her Lesson Study experience. She believes that Lesson Study could promote teachers' collaboration towards acquisition of new knowledge and skills required in teaching specific lesson content. This was observed when she said:

> *I feel this is a kind of workshop that could help teachers work together to find better ways of teaching a concept instead of this practice where a senior teacher reteaches the content of a lesson to the junior teacher. I like the fact that it is focused on how learners learn and not on content…. You see I believe if this kind of workshop is well planned and not giving us teachers information at the last minute when the workshop is to take place it can yield a good result.(Martha, interview).*

From Martha's response, it is possible that structured collaborative activities during Lesson Study could result to improved teachers' knowledge, good working environment and possibly increase learners' achievement.

5.12.2.3 Teacher's knowledge

During the interview, Martha explained how the collaboration phase of Lesson Study influenced her professional knowledge and practice. She said:

> This was a great opportunity to work with a teacher teaching the same grade level within my cluster. You *know collaborating with my HOD and the other teachers in my school is something we just spend ten to fifteen minutes to clarify whatever thing it is I have. But now working together with this teacher from another school, we were able to discuss few areas where learners have problems in this knowledge area of electricity and magnetism; and I think his approach to the practical demonstration on magnetic field lines were quite helpful. I also think that I have been able to build a network with him which I think is going to be very useful for me in terms of building a professional network outside the school where I teach.(Martha, interview).*

It seems that working together with colleagues in this study improved Martha's practical knowledge on how to perform an effective demonstration with learners. This was observed when Martha indicated that Alex's suggestions that learners should observe, draw and explain what they have observed and compare with diagrams in their textbooks improved her knowledge on how learners could draw patterns of the magnetic field through effective practical demonstrations. Though Martha did not specify on how the collaborative phase of this study improved her knowledge, she said in her own words:, "*I did realise that there were some few things I actually learnt from you and him which probably I could not have known on my own".* This implies that collaboration between teachers helped in improving her own knowledge construction. However, it seems that this was not perfect because teachers were unable to detect and discuss wrong answers during their reflection.

5.12.2.4 Teacher's attitudes and beliefs

During the interview, Martha indicated that she usually reflects on her learners' learning based on emotions. However, it seems that participating in this study had a positive impact on how Martha reflected on her learners' difficulties. This was observed when she was asked:

Researcher: *How has participating in this study influenced your classroom teaching practice?*

Interviewee: *Like I said earlier, I do my reflection whenever I have this feeling that I had a bad lesson and I just go back to re-explain the lesson again but during our first meeting, Mr Alex's suggestion on the idea of allowing learners to observe, draw and discuss the magnetic field lines around the magnet made me realise that I could develop new ways of teaching the learners the same lesson if I take my time to critically reflect on the method I used in teaching the lesson before and not just re-teaching using the same method. That's why I did less of talking during the discussions so I can critically look into my practice to check if it's on track.*

Martha's views on the impact of Lesson Study on her professional practice was also indicated during her reflection on the most important aspect of her Lesson Study experience (see Section 5.12.2.1 and Appendix 18B). It seems that participating in this Lesson Study intervention had a positive impact on Martha's practice in terms of lesson plan writing. This was observed when she indicated that if she has to write a lesson plan, then she has to think of what to write, make sure it is what the CAPS document requires, and ensure that it is relevant to her lesson. This implies that participating in this study has positively changed Martha's understanding of reflection as well as increased her knowledge of lesson planning which is captured by writing. However, it was observed that Lesson Study did not change Martha's attitude to practical work since she did not conduct the planned practical activity and also said nothing about practical work in her reflection.

5.12.2.5 Contextual factors and challenges

Martha indicated that finding time to participate in a professional development programme is a major challenge that might affect teacher's continuous practice of the Lesson Study process. She believes that teachers don't have the luxury of time since the teaching period allocated to cover the syllabus is short considering the holidays in between the academic terms. This was indicated in the conversation below.

Researcher: *Are there any factors that might possibly affect your continuous use or practice of Lesson Study as a teacher?*

> ***Interviewee:*** *I think the time is the main factor because our learners struggle with the pace of physical sciences. For instance, in Grade 12, we just introduced organic chemistry and the time allowed in the CAPS document is not nearly enough to cover all the content that learners need to know. And we have too many public holidays which shortens the term. For instance, I asked learners to come for afternoon lessons every Tuesday they gave excuses I changed it to Wednesdays they gave excuses so their attitude to learning might probably not make this work as well if you can understand.*

From her response, it seems that Martha's beliefs about learners' negative attitude to learning could hinder her Lesson Study practice. However, she indicated that she cannot continue teaching the same topic when she has a lot to cover in a short time. It seems Martha was also concerned about her workload and job responsibilities as possible contextual factors. This was observed when she indicated that she has not covered her lesson content in physical sciences and other subjects she is teaching, as the term is coming to an end. During Martha's reflection on the most challenging phase of her Lesson Study experience, she indicated time as a challenge and indicated that teachers don't have time to observe each other's lesson presentation as prescribed in Lesson Study. She also mentioned that many teachers will not be interested in Lesson Study because teachers sometimes view participation in professional development programmes as an additional burden. She believes that participating in Lesson Study is an additional responsibility which requires hard work, commitment and time. This implies that teachers' interest, beliefs and attitude could be a possible contextual factor that influences their intent and continuous practice of Lesson Study.

5.13 **Analysis of participants' documents**

The participants' documents used in this study are the teacher's original lesson plans before participating in the study. Lesson plans are used by teachers to capture and document how to coordinate the teaching and learning process for a specific lesson. Findings from the teacher's original lesson plan are discussed based on the guidelines provided in Appendix 12. The elements to be discussed in the analysis of the teacher's lesson plans include an outline of goals and objectives for the lesson, reflection on learners' previous knowledge, teacher's inquiry methods, class activity based on practical demonstration, evidence of learners' class activities and feedback.

5.13.1 Alex's original lesson plan before the research

Prior to participating in this study, Alex presented his lesson plan on magnetism. His original lesson plan contained scribbled notes which reflect the date, points to be discussed in the class and content to be covered while teaching the lesson. All other elements of a structured lesson plan were missing from his prepared lesson plan. His lesson plan did not make provision for teacher's description of how the lesson fits into a larger curricular unit, the method of assessing learners, teaching methods to be used, feedback on learners' learning and lesson conclusion. There was no provision for teacher's reflection on the lesson taught. A picture of note presented as Alex's lesson plan on magnetism at the initial interview is provided in Figure 5.29.

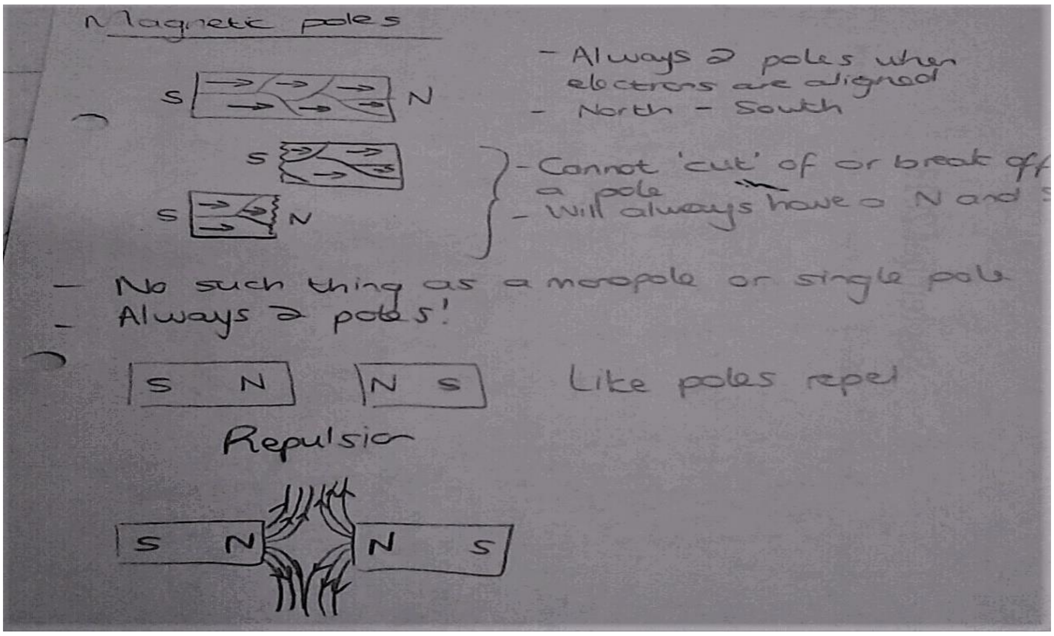
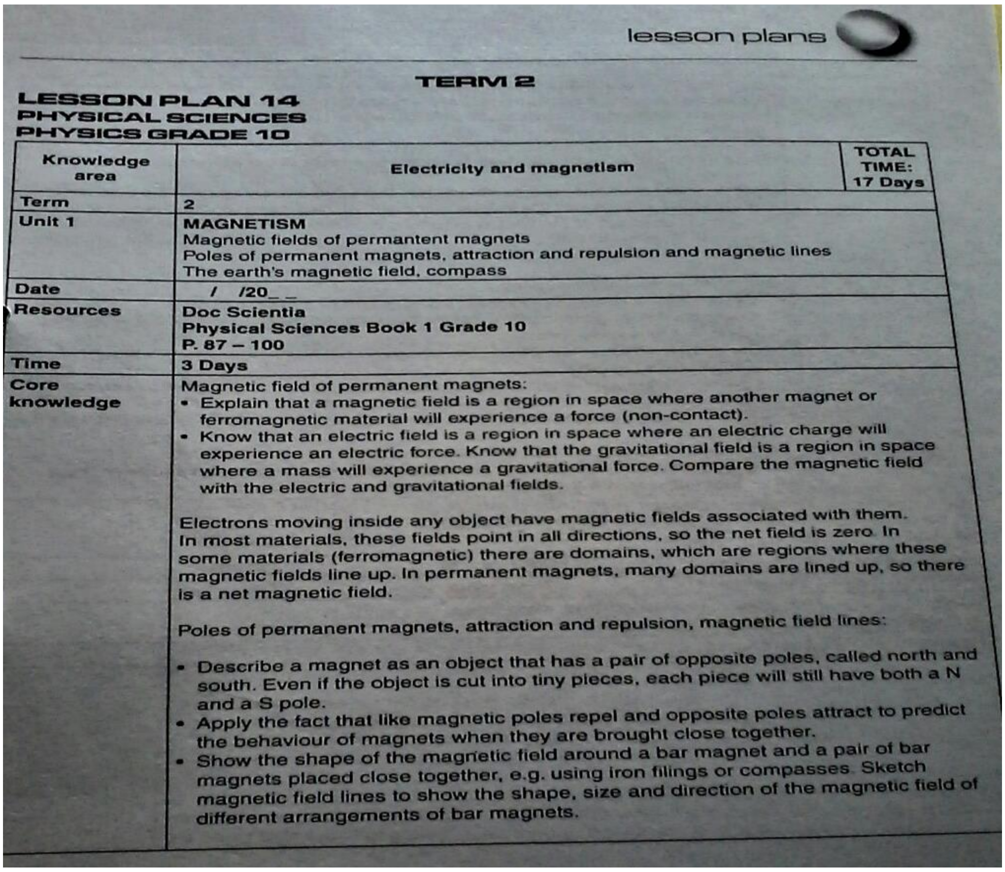


Figure 5-29: A copy of Alex's original lesson plan on magnetism before participating in the study

5.13.2 Martha's original lesson plan before the research

Prior to participating in this study, Martha presented a readymade lesson plan on magnetism from CAPS as her original lesson plan. The lesson plan made provision for various sub-headings like knowledge area, term, unit, date, resources, time, core knowledge, activity, assessment methods and extra resources for learners' self -study and homework. Analysis of the developed lesson plan reveals that the template did not make provision for lesson objectives; discussion on how to assess learners' previous knowledge and the teacher's reflection on the lesson taught. It is nderstood that not all lesson plans are the same however, a lesson plan should cover detailed information of the teacher's instruction for a specific lesson. A sample of the developed lesson plan used by Martha is shown in Figure 5.30.


lesson plans

TERM 2

LESSON PLAN 14
PHYSICAL SCIENCES
PHYSICS GRADE 10

Knowledge area	Electricity and magnetism	TOTAL TIME: 17 Days
Term	2	
Unit 1	MAGNETISM Magnetic fields of permanent magnets Poles of permanent magnets, attraction and repulsion and magnetic lines The earth's magnetic field, compass	
Date	/ /20_ _	
Resources	Doc Scientia Physical Sciences Book 1 Grade 10 P. 87 – 100	
Time	3 Days	
Core knowledge	Magnetic field of permanent magnets: • Explain that a magnetic field is a region in space where another magnet or ferromagnetic material will experience a force (non-contact). • Know that an electric field is a region in space where an electric charge will experience an electric force. Know that the gravitational field is a region in space where a mass will experience a gravitational force. Compare the magnetic field with the electric and gravitational fields. Electrons moving inside any object have magnetic fields associated with them. In most materials, these fields point in all directions, so the net field is zero. In some materials (ferromagnetic) there are domains, which are regions where these magnetic fields line up. In permanent magnets, many domains are lined up, so there is a net magnetic field. Poles of permanent magnets, attraction and repulsion, magnetic field lines: • Describe a magnet as an object that has a pair of opposite poles, called north and south. Even if the object is cut into tiny pieces, each piece will still have both a N and a S pole. • Apply the fact that like magnetic poles repel and opposite poles attract to predict the behaviour of magnets when they are brought close together. • Show the shape of the magnetic field around a bar magnet and a pair of bar magnets placed close together, e.g. using iron filings or compasses. Sketch magnetic field lines to show the shape, size and direction of the magnetic field of different arrangements of bar magnets.	

Figure 5-30: A copy of the original prepared lesson plan used by Martha

A summary of the teaching strategies found in the analysis of pair B's original lesson plan before participating in Lesson Study is presented in Table 5.5. However, the final lesson plans presented at the end of the Lesson Study intervention by pair B addressed the criteria outlined in Table 5.5 (see Appendix 20).

Table 5-5: Comparison of lesson study pair B's lesson plans

Criteria	**Initial lesson plan**		**Final pair plan**
	Alex	**Martha**	
Teacher's description of how the lesson fits into a larger curricular unit			f
Activities in teacher planning that assessed or stated learners' prior knowledge			f
Outline of inquiry methods to be used while teaching the lesson		i	f

Outline of teacher’s expectation of what learners should know and be able to do at the end of lesson			f
Instructional materials teacher used in the class while teaching the lesson		i	f
Content/procedure standard	i	i	f
Teacher’s feedback to learners			f
Teacher’s wrap up/ conclusion			f
Planned learners’ assessment		i	f
Notes for teachers to reflect on the lesson taught.			f

i = found in the initial lesson plan, f = found in final lesson plan

Analysis of lesson study pair B’s initial lesson plans revealed that the lessons were content driven. However, the lesson plan template and researchers’ questioning stimulated teachers’ awareness of and caused them to think about learners’ learning, thereby shifting their focus from teacher-centered to learner-centered teaching.

5.14 **Conclusion**

This chapter presented the analysis of data collected from two Grade 10 physical sciences teachers from two different city schools. The data were obtained through interviews, Lesson Study meetings, lesson observations as well as document analysis of teachers’ reflective writings and original lesson plans before participating in this study. The trustworthiness of the data obtained in this study was enhanced by the triangulation of information obtained from participants’ interviews, lesson observations and documents. Results obtained from Lesson Study pair B revealed the following:

- Before this study, Alex and Martha were not in the habit of writing lesson plans. They believed that writing a lesson plan takes a lot of time. During the first planning session, teachers struggled with the provided Lesson Study plan template. Further involvement in the study improved their knowledge of the components of a good lesson plan (Section 5.5, Section 5.12.2 and Section 5.13.2.1).
- Martha indicated during the initial interview that she only reflects on her lesson when she feels the lesson is not good. Participating in this study changed her perception of reflection. It also increased her awareness on the use of reflection as a way of interacting with others to develop personal and intellectual inquiry practices that can promote learners’ interest in a lesson, and possibly a change in teachers’ pedagogy.

- Alex and Martha mentioned that they rarely engage in professional collaborative activities focused on physics content. Participating in this study provided them the opportunity to build a teacher network focused on developing the teaching and learning of physics content.
- Teachers indicated that the presence of a visitor or an outside observer in the class improved their learners' concentration level. This implies that participating in this study improved teacher's awareness on the importance of classroom observation in improving classroom teaching procedures, learners' attentiveness and assessing learners' performance.
- Participants demonstrated knowledge of various teaching strategies during the initial interview. They mentioned a problem-solving approach, explanation, use of simulations, analogies, practical activities and demonstrations as teaching methods employed in addressing learners' difficulties. In contrast, Martha was not observed involving learners in problem-solving and practical experiment activities. She explained solved activities based on her PowerPoint presentations and asked learners to write them down in their notebooks. No changes were observed or found during the Lesson Study intervention. However, participating in this study improved Alex's awareness of the importance of using real-life applications of specific concepts as a teaching pedagogy.

In the next chapter, the results obtained in this study are related to existing literature, a discussion on the summary of the research findings is presented, as well as the researcher's personal reflection, limitations to the study, implications, recommendations and the conclusions of the study.

6. CHAPTER 6: DISCUSSION, IMPLICATIONS AND CONCLUSION

6.1 Introduction

Findings obtained from this study were presented in Chapters 4 and 5. In this chapter, a summary of all the chapters, followed by a discussion of results obtained according to themes structuring the research findings is presented. Next the research questions are revisited, the researcher's reflection is presented and the limitations, contributions, implications, recommendations and conclusions of the study are discussed.

As a teacher, I came to understand that physical sciences learners find it difficult to satisfactorily interpret and answer questions on electricity and magnetism due to the abstract nature of the topic. Research has outlined teachers' professional knowledge, skills, beliefs, attitude and practice as possible factors responsible for learners' poor performance in physical sciences. The problem that puzzled me as a researcher was finding ways of enhancing physical sciences teachers' professional knowledge and classroom practices about teaching electricity and magnetism. Research has documented Lesson Study as a collaborative professional growth model focused on improving teachers' professional capability and learners' outcome. Based on this idea, my study was designed to understand participants' views and behaviour when teaching electricity and magnetism during a Lesson Study intervention.

6.2 Summary of chapters

In Chapter 1, the background and context of the research study were introduced and presented. This study explored physical sciences teachers' use of Lesson Study as a school-based professional development model in the teaching of electricity and magnetism. The rationale for the study was discussed, three research sub-questions were formulated and briefly discussed and the methodological considerations and the possible contribution of the study to the body of knowledge was discussed..

In Chapter 2, the researcher gave an in-depth review of relevant literature underpinning this study and critically reviewed literature on the importance of physical sciences as a subject. Several findings and literature on learners' difficulties in electricity and magnetism was discussed. Comparisons were made between different notions of physical sciences teachers' professional development needs internationally and nationally, followed by a discussion of relevant studies on physical sciences teachers' effectiveness. Attention was given to the various aspects of teachers' certification, teachers' professional knowledge, and teaching quality. Studies on factors affecting the successful implementation of Lesson Study and its advantages were reviewed. The researcher also discussed the constructivist and andragogy theory as a theoretical framework that supports the use of Lesson Study in her research work. Lastly, a conceptual framework for Lesson Study as a teacher professional development was presented.

In Chapter 3, a description of the methodology employed in this study was discussed.. Interpretivism as the research paradigm as well as the researcher's subjective and interpretive approach to the study were also discussed. Lastly, the research design as an exploratory case study of sampled physical sciences teachers' Lesson Study practice was described. An in-depth exploration of teachers' knowledge and experiences was conducted through semi-structured interviews, classroom observations and Lesson Study pair meetings. Teachers' documents such as initial lesson plans before participating in the study and reflective writings were also collected for data analysis purposes. The data analysis strategies and criteria for quality assurance were discussed. The researcher lastly discussed ethical concerns and possible limitations to the study.

In Chapters 4 and 5, the results of the data analysis for the two Lesson Study pairs were discussed separately. Pair A was from a rural school and pair B was from two different city schools. Transcripts were coded and analysed, and all emerging codes generated from the data were later grouped according to categories identified in the literature, and themes created for this study. The findings of data obtained during the interviews, Lesson Study planning sessions, teachers' classroom teaching, Lesson Study reflection sessions, and analysis of participants' documents were presented.

6.3 Situating the research findings

In order to situate findings from this study within a meaningful context, the data obtained was analysed using content analysis. A total of 206 codes were created from the transcriptions of the initial and final interviews conducted with the participants. These codes were further categorised into 30 sub-themes that were developed based on reviewed literature and finally assigned to two emergent themes and three a priori themes based on the research questions. The research sub-questions for this study were used as a framework to manage, analyse and discuss the data obtained in this study. Keeping the research framework method in mind as discussed in Section 3.6, the following three a priori themes were created:

- Teachers' knowledge (revealed during interview, original lesson plan, classroom and group observation)
- Teachers' attitudes and beliefs (revealed during interview and participants' reflective writings)
- Contextual factors and challenges (revealed during interview and field notes)

Correspondingly, the following two themes emerged during the data analysis:

- Teachers' collaboration (revealed during interview, original lesson plan, classroom and group observation)
- Lesson Study experience (revealed during interview, group and lesson observation)

In the following subsections, discussions of the obtained results with respect to themes of this study were presented.

6.3.1 Theme 1: Teachers' knowledge

The meaning of teachers' knowledge as used in this study has been explained in Section 4.5.1.2. During data analysis, some of the data obtained were directly linked to the theme **teachers' knowledge** as shown in Figure 6.1. The data converged into five common categories**/**sub-themes that emerged from codes generated during analysis of teachers' original lesson plans, classroom observation and the initial interview. Therefore, teachers' knowledge was interpreted in terms of the categories: content knowledge, knowledge of learners' difficulties, teaching strategies, teachers' qualification and knowledge of lesson planning and writing, as illustrated in Figure 6.1.

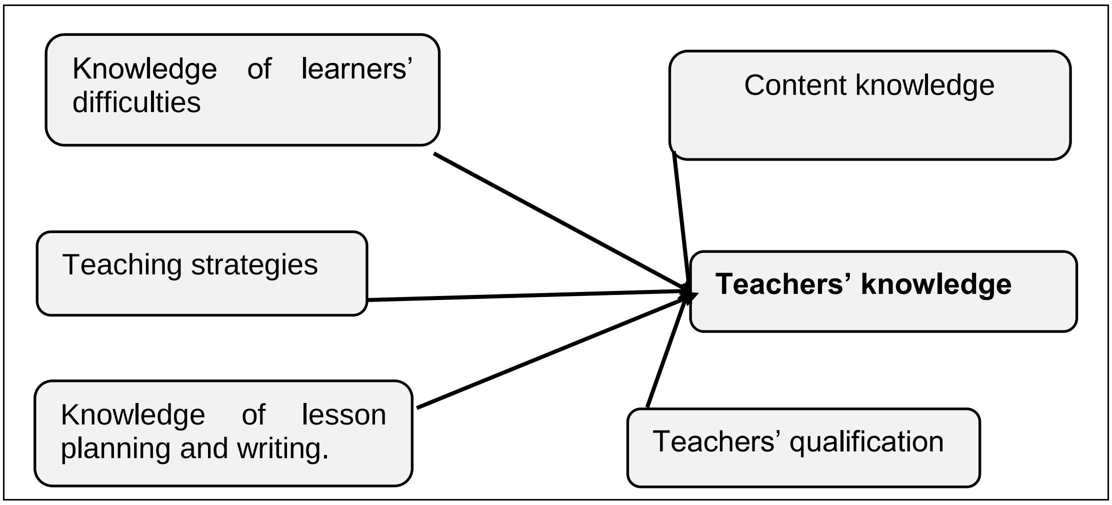


Figure 6-1: Teachers' knowledge

The theme teachers' knowledge relates to participants' demonstration of the foundational knowledge required for teaching electricity and magnetism. Research indicates that the foundational knowledge required by a teacher must include teachers' qualification, certification, teaching experience, knowledge of learners' learning, content knowledge, pedagogical content knowledge, general pedagogical knowledge, knowledge of the curriculum, knowledge of educational contexts and knowledge of educational aims (Darling-Hammond, 2000; Liakopoulou, 2011; Shulman, 1987). It is possible that these foundational knowledge types could be valuable in drawing special attention to knowledge areas where teachers may need to improve on.

Results obtained during the initial interview suggested that participants' qualification provided them with the basic knowledge required to teach physical sciences as a subject. Martha and Alex qualified at the degree level while Lenox and Mbali qualified at the diploma level. Therefore, it seems that Lenox and Mbali may lack the in-depth knowledge required to teach the subject due to their qualification, because studies have shown that physical sciences teachers without major qualification in either physics and/or chemistry could lack the in depth knowledge of the subject content and required pedagogical knowledge (Basson & Kriek, 2012; Mji & Makgato, 2006). Participants in the study also have a teaching experience ranging from three years to eighteen years. So, it is assumed that participants' years of experience should provide them with the cognitive understanding of specific content knowledge and learners' difficulties in electricity and magnetism.

Teachers' knowledge of learners' difficulties in specific lessons is a critical factor that enhances the teaching and learning process (Ausubel, Novak, & Hanesian, 1978). Initial interviews and Lesson Study planning meetings revealed that participants are knowledgeable of their learners' learning background and difficulties in electricity and magnetism. Mbali said:

> *In electricity, learners don't know how to correctly substitute equations when solving problems and funny enough am still shocked that these learners can neither state nor apply Ohms' law correctly.*

This was also mentioned by Martha when she said:

> *Taking a critical look at Grade 10 and 11, basically, I will say it's the maths especially when you get to the series resistor, parallel resistor and combine effect of both series and parallel circuit connection. They don't know how to do conversion. (Martha.interview)*

Alex indicated that learners don't understand the concept of resistance in a parallel circuit and they find it difficult to understand when current splits and divides into a circuit. Lenox stated that learners find it difficult to differentiate between parallel and series connections, especially in a complex circuit and they don't understand the difference between electromotive force and potential difference. All four participants believe that learners across Grade 10, 11 and 12 struggle with the mathematical analysis of electric circuits and application of Ohm's law (DBE, 2015; Engelhardt & Beichner, 2004). One of the participants also indicated that learners have the same fear for the electric circuit as they have for mathematics. This implies that learners' difficulties in electricity are sometimes based on learners' perception of the topic. This supports the notion that learners' perception is linked to the attitude developed towards such a topic or subject and this influences their understanding of that topic (Gebbels, Evans & Murphy, 2010).

Apart from the general perception of learners' difficulties across the entire FET phase, participants also believe that there are some difficulties in electricity and magnetism that are peculiar to a specific grade level. According to the participants:

Martha: *For Grade 11 there is this big problem when it comes to magnetic flux. It is a difficult concept for the learners.*

Alex: *In Grade 11, the major problem is electromagnetism. You know there is no detail explanation on how electricity and magnetism relate so you just teach the relationship based on textbooks and learners still can't comprehend the relationship between the two. Understanding magnetic flux and the magnetic field strength are very much confusing to learners because it's closely related. Learners also struggle with this concept of induced magnetic field, left-hand rule, and right-hand rule.*

Lenox*: In electromagnetism learners find it difficult to identify the direction of magnets in a solenoid. Also, this in-page and out of page description in the curriculum or the textbooks are not explanatory enough to some of them. Another thing I may say is that these learners don't really understand the meaning of the change of magnetic flux and because of this when they are asked some questions they don't know that changing the area of a coil will automatically change the flux.*

Mbali: *They struggle with Faraday's laws of induction, the direction of the induced current, magnetic field, solenoid and how to determine the direction of the field at particular angles. Something I think........ I noticed as well is that some learners take the direction of the field as the flow of current. Then you see this concept of a magnetic field associated current carrying wires.... yooo, it is confusing to learners and even to some educators. In electricity, learners don't know how to correctly substitute equations when solving problems and funny enough am still shocked that these learners can neither state nor apply Ohms' law correctly.*

All four participants indicated that learners struggle with concepts like magnetic flux, magnetic field strength, induced magnetic field, identifying the direction of magnets in a solenoid, Faraday's laws of induction, direction of induced current, solenoid, left hand rule, right hand rule and how to determine the direction of field at specific angles which are related to electromagnetism. Participants' knowledge of learners' difficulties in electromagnetism are in agreement with and well documented in literature (DBE, 2015; Koudelkova & Dvorak, 2014; Raduta, 2005; Saglam & Millar, 2006).

Teachers' professional knowledge also includes their knowledge of the specific subject matter. Difficulties and misconceptions are not only peculiar to learners but also persist among teachers. For instance, research indicates that teachers also encounter difficulties and have misconceptions in specific topics as their learners do.(Kriek & Grayson, 2009; Sadler & Sonnert, 2016). During the interview, Martha indicated that it helps to know that teachers also find it difficult to understand some content, because then they can identify possible learners' problems and find ways of solving such problems. In fact, all participants indicated that they also find it difficult to understand some concepts on electromagnetism and they rarely have an opportunity to engage in collaborative activities aimed at improving their own content knowledge. Teachers' reflection on the concepts they find difficult and their familiarity with learners' difficulties give them the opportunity to plan the difficult lessons in a better way that learners can understand. Participating in this study also gave Mbali and Lenox the opportunity to develop pedagogical approaches that supported their own understanding of difficult concepts in electromagnetism. Participants' understanding of learners' difficulties in electricity and magnetism was the main factor that influenced teachers' Lesson Study planning and the assessment of their pedagogical skills.

Before participating in this study, participants mentioned several traditional teaching methods like direct teaching, explanation, and illustration as methods they have been using to address learners' difficulties in electricity and magnetism. During the Lesson Study pair planning meetings and classroom observations, participants' pedagogical practice was modified in agreement with their reflections and discussions on how best to teach concepts in electricity and magnetism, similar to the situation described by Park and Oliver (2008). During the lesson observation, the researcher found that participants demonstrated their ability to teach the identified difficulties for their respective classes by re-contextualizing the lesson content using different teaching strategies like learners' engagement in guided problem-solving approach, practical activities, and demonstrations suitable for their learners. This implies that during the Lesson Study intervention, participants incorporated new strategies to improve their teaching as compared to their initial practice before participating in this study. This is also a representation of participants' pedagogical practice and general pedagogical knowledge in teaching specific concepts (Jones & Straker, 2006; Shulman, 1987).

Participants' teaching knowledge before participating in Lesson Study was also assessed using document analysis of their original lesson plan. The four teachers in my study did not use comprehensive lesson planning prior to participating in the research. It was observed that two of the teachers presented scribbled notes as their lesson plans, one of the teachers presented a lesson plan used in the previous year while the other teacher presented a lesson plan available in the CAPS document. However, participating in the collaborative lesson planning session of this study improved participants' attitudes, skills, and knowledge on how to design a detailed lesson plan. During the interview, participants reflected on how they struggled with the Lesson Study plan template given to them during the collaborative lesson planning session of Lesson Study. For instance, Martha indicated that she struggled with the concept of anticipating learners' response while writing the lesson plan for the research lesson. She indicated that writing the developed lesson plan increased her knowledge of effective lesson plan writing. The researcher also observed during the classroom teaching that all four participants presented their lessons logically and consistently focused on achieving the objectives outlined during the Lesson Planning session which was not indicated in their original lesson plans. The final lesson plans presented at the end of the Lesson Study intervention by the two pairs showed an improvement in teachers' knowledge of lesson planning (see Table 4.7 and 5.5, Appendix 15 and 20).

6.3.2 Theme 2: Teachers' collaboration

Collaboration is a state of agreement where people work together with the same interest to improve or provide a solution to a problem (Lai, 2011). Collaboration in education is viewed as a learning philosophy where a group of individuals (teachers and/or learners) work together with the same interest of improving teachers' practice and learners' learning (Laal & Ghodsi, 2012). Teacher collaboration within the context of this study refers to the agreement between selected physical sciences teachers to come together with a mutual goal of exploring better ways of addressing learners' difficulties in electricity and magnetism using Lesson Study as an action research model. Social constructivism as a theoretical framework underpinning this study supports teachers' collaboration through interaction with peers. Moreover, Lesson

Study is a continuous professional growth model that allows teachers to collaboratively plan, teach, observe and reflect on a lesson.

The theme **teachers' collaboration** as used in this study emerged from codes generated during analysis of participants' interviews and joint planning of research lessons. The emerged codes were grouped into five categories as illustrated in Figure 6.2.

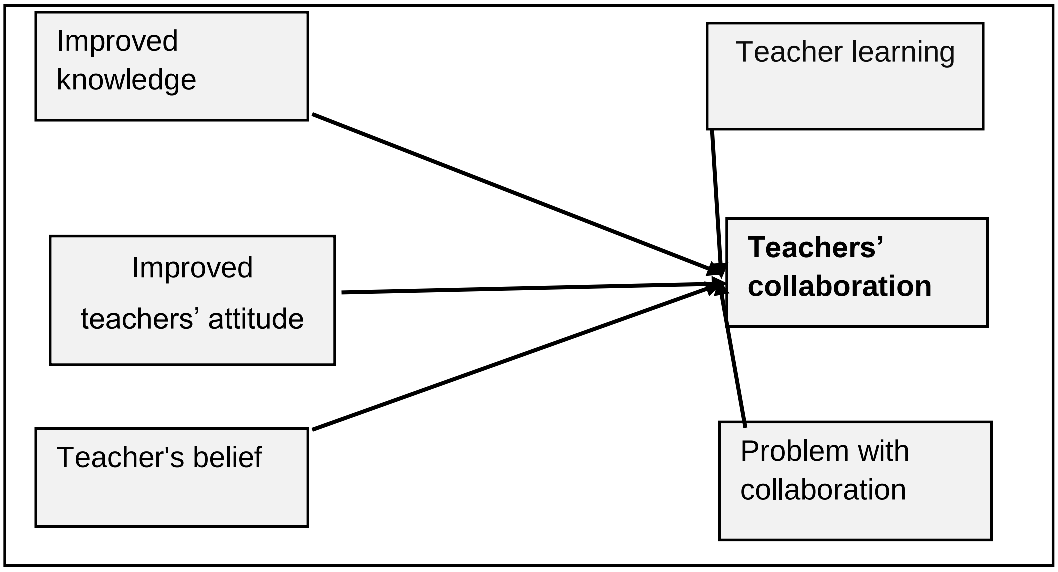


Figure 6-2: Teachers' collaboration

During the initial interview, participants reflected on difficult concepts in electricity and magnetism. Lenox, Alex, and Martha indicated that they still struggle with lesson contents related to electrodynamics, motors and generators in the Grade 12 syllabus. On the other hand, Alex and Mbali indicated that they still struggle to teach some concepts in electromagnetism. Discussion on how participants engage with their colleagues to address topics they perceived as difficult revealed that the participants rarely collaborate with teachers' within or outside their school. Data obtained reveals that Martha and Alex believe in using more of a self-study approach to improving their understanding of difficult topics as teachers, rather than talking to people about their challenges. However, Lenox, Alex, and Martha indicated that they do engage in short discussions with their departmental head and other colleagues to discuss urgent classroom challenges. Mbali, on the other hand, has not had the opportunity to discuss her challenging lessons with any teacher. This could possibly mean that participants don't engage in effective collaboration activity with colleagues because they don't get the necessary support from education stakeholders. This was observed during the final interview, when Alex indicated that effective participation of teachers in collaborative activities requires getting support from the school and respective stakeholders in the education system. Based on their responses, the researcher found that the participants know what collaboration entails but they don't often engage in collaboration because of the time factor, an ineffective support system that promotes teacher collaboration, their beliefs or attitude, behaviour, and message they get from some colleagues or leaders as described by Piercey (2010).

Researchers and education policymakers have identified collaboration as a major skill that promotes an effective teaching and learning process. For instance, Bellanca (2010) claimed that the Partnership for 21st Century learning has identified collaboration as a critical communication skill required for success at schools and places of employment. This was also indicated in an educational initiative called Common Core State Standards for K-12 learners in the United States (Lai, 2011). Since participants don't frequently involve themselves in collaborative activities, their participation in this research study gave them the opportunity to work together as pairs in their respective schools. Participants jointly explored how the Lesson Study process could be used as a collaborative approach to inquire, plan and address learners' difficulties in electricity and magnetism. Teachers participation in this study also created an opportunity for them to implement the action research strategy of the Lesson Study process and use similar research practices in their classrooms.

During the final interview, participants expressed their ideas, beliefs, and views on the benefits of collaborating with their colleague while participating in this study. All four participants believe that working together with another teacher and an expert in the field has helped improve their professional knowledge. In terms of pedagogical knowledge, Lenox stated that working together with his colleague has improved his teaching skills and he has learned a new approach to teaching some concepts. Alex mentioned that relating to a professional expert has made him realise the significance of letting learners know that for instance circuits are everywhere in our phones, television, sound system and all that. According to Martha, "working together with a teacher from another school, we were able to discuss few areas where learners have problems and I think his approach to the practical demonstration on magnetic field lines were quite helpful". In terms of content knowledge, Mbali indicated that her understanding of electromagnetism was a bit upgraded. These findings confirm that participating in Lesson Study helps to improve teachers' knowledge of subject matter in terms of content knowledge, pedagogical knowledge and general pedagogical knowledge as found by (Cajkler et al., 2015; Lewis & Hurd, 2011).

Participants also mentioned an improvement in their attitude in terms of confidence and competency as one of the benefits of collaborating with their colleague while participating in this study. Mbali indicated that the collaboration process has helped her to gradually reduce her habit of planning and teaching in isolation. This was also declared by Lenox when he said this opportunity has helped him to use his classroom experience to increase his colleague's confidence. This finding reflects the result of Rock and Wilson (2005) where participants reported an increase in their professional confidence after participating in Lesson Study.

Mbali revealed that working together with her colleague in this study has helped her build a working and friendly relationship. Martha, on the other hand, stated that working together in this study has given her the opportunity to build a professional network with her colleague teaching the same grade level from outside her school. The researcher found that participants' views on the professional learning community was based on their personal experience and what they have learned during their participation and collaborative work in this study. The social constructivist theory discussed in Chapter 2 focuses on how the interaction between participants supports learning through learning communities. This also indicates that partaking in Lesson Study assists teachers to collaboratively make sense of new ideas from inside and outside their school (Lewis & Hurd, 2011). The findings confirm Cerbin and Koop's (2006) argument that participating in Lesson Study helps teachers build a professional community of practice around teaching.

During the final interview, Mbali's reflection points out teacher's beliefs as one of the problems of collaboration. She indicated that Lesson Study might not work since she believes that teachers would be heavily criticised by their colleagues and it could lead to demoralising scenarios among teachers. This statement implies that issues regarding the use of formal or informal powers when teachers collaborate within the

Lesson Study context needs to be properly addressed. During Lesson Study, teachers need to establish rules on how to share and exchange of ideas or resources among peers, build trust among each other and promote a peaceful resolution of conflicts (Dudley, 2014).

The role of teacher collaboration during Lesson Study as indicated by participants, helped them to have a sense of belonging thereby building a work environment relationship. Collaboration enabled them to open their class to colleagues and observers in order to learn from one another, and also increased their confidence and competency which is one of the characteristics needed to be an effective teacher. In conclusion, the theoretical perspective of social constructivism gave participants the opportunity to collaboratively improve their knowledge about effective teaching as they develop a community of practice. The findings support Pang and Ling's (2012) report which claims that the collaborative nature of Lesson Study helps to break teachers' isolation .

6.3.3 Theme 3: Teachers' attitudes and beliefs

Attitude can be described as the way an individual's personality, beliefs, values, behaviours, and motivations attained from experience are expressed through words and behaviour (Ambusaidi & Al-Farei, 2017; Gun, 2012). It is believed that teachers attitude can negatively or positively influence their classroom practice. This implies that teachers' classroom practices does not depend on knowledge alone but also on attitude, conceptions, opinions, self-regulation and motivational characteristics (Blömeke & Delaney, 2012; Ernest, 1989).

Teachers' participation in Lesson Study is not a one-way process but rather a continuous and iterative process which allows teachers to work together with colleagues or learners and sometimes work alone during a free period. This gives teachers the opportunity to have a first-hand experience and discuss how participating in Lesson Study influenced their beliefs, attitudes and classroom practices. The theme teachers' attitude and beliefs emerged during the analysis of participants' interviews, discussions on the effect of learners' difficulties and participation in Lesson Study on their classroom practice, and reflective writings. After participating in this intervention programme, participants' interview response to the effect of the Lesson Study process on their practice were grouped into six categories: teachers' knowledge and beliefs about learners' difficulties, belief about pedagogical practice and teaching methods, teachers' attitude towards teaching, teachers' reflection, teachers' professional development needs, beliefs about teachers and learners' learning.These categories were grouped as the theme 'beliefs and attitudes' as illustrated in Figure 6.3.

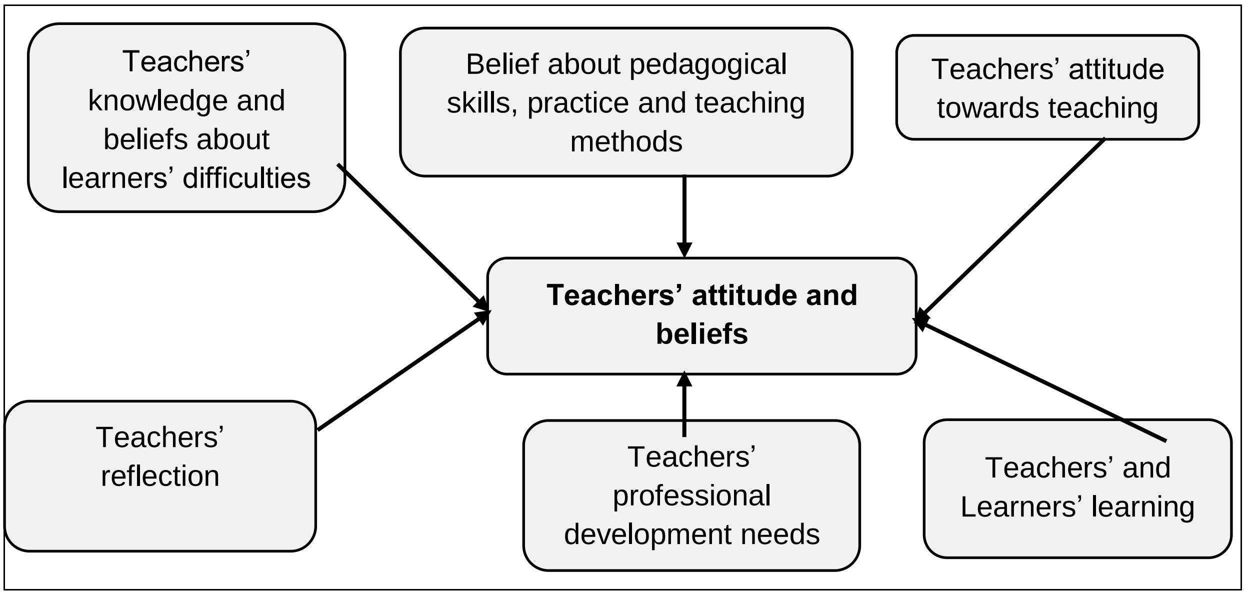


Figure 6-3: Teachers' attitude and beliefs.

During the initial interview, all four participants indicated that learners' difficulties affect their classroom teaching. They all believed that addressing learners' difficulties and misconceptions during a lesson consumes most of their allocated teaching time. For instance, this was observed when Martha said, "teaching learners to understand the basics before teaching my main lesson is cumbersome and consumes most of my teaching period". Similarly, Mbali indicated that learners' background and attitude to homework also affects her classroom teaching. This was observed when Mbali said she spent most of her teaching period doing the homework given to learners. It seems that teachers' attitude in terms of how much importance they give to addressing learners' difficulties during their teaching is not clear. However, it is possible that the expectations of these teachers and their different behaviours to learners could possibly influence their attitude and belief towards instructional change.

Alex, Lenox, and Mbali also indicated that learners' difficulties affected their attitude to teaching and pedagogical practice since they tend to repeat instruction. Lenox's interview response revealed that he has a negative attitude towards learners' difficulties. This was confirmed when he said he sometimes continued with his teaching without clarifying the difficulties. This may indicate that teachers' lack of interest on specific topics the teachers don't understand could affect the teachers' attitude when teaching these topics to learners. These attitudes which include the teachers' lack of competence and confidence due to a poor teachers' understanding of physics content may negatively affect their classroom practice and learning environment. However, he indicated that collaborating with colleagues in this study helped improved his attitude towards teaching some difficult physics concepts. Results obtained from this study align with a study conducted by Rock and Wilson (2005) which reported an improvement in teaching attitude and increase in the professional confidence of Lesson Study participants.

Findings from the final interview also reveals that participating in this study improved participants' competency and attitude towards teaching physics concepts that appear confusing to both teachers and learners. For instance, Mbali indicated that when teaching electromagnetism, she previously taught the lesson content and avoided answering some questions that learners ask. However, participating in Lesson Study has changed this attitude by helping her to bring down the wall she has built around her when teaching concepts related to electromagnetism. This was also observed during her classroom teaching where she confidently answered learners questions on "in page" and "out of page" using her thumb as discussed during the lesson planning meeting, as opposed to her previous attitude of avoiding such questions. Lenox believes that a teacher can be teaching for many years and still have some negative attitude in terms of lack of confidence teaching specific topics, probably because they don't like those topics. He indicated that participating in Lesson Study has gradually helped him to build his self-confidence in some aspects of physics that appeared challenging to him. Participating in this Lesson Study intervention also created an experience which helped participants to reflect on their existing beliefs about learners' difficulties and their teaching methods, as they became open to alternative approaches, thereby improving their willingness to learn and adjust their classroom practices. The opportunity to reflect on their attitude towards teaching physical sciences impacted their perception and views about teaching physics concepts that are critical and more challenging to individual participants. For instance, Alex previously did not relate his lesson to real life experience since he believed that learners already knew the application of most science lessons in their immediate environment. So, Alex just goes straight to teaching the theoretical aspect of the lesson. However, participating in Lesson Study changed his beliefs and attitude on the use of authentic tasks and real-world connection in relating his lessons to learners. Lenox on the other hand previously used a lecture approach in teaching physics concepts. Nevertheless, during a previous informal conversation, he had mentioned that lecture method is convenient and he had been taught by the method. However, during the final interview, he indicated that participating in Lesson Study had changed his intuitive understanding and insight about learning physical sciences through visualising physics concepts in a more practical way than before. The findings are in substantial agreement with other findings that claims that experiences gained through interaction, continuity, and wholeness brings contemporary changes to teachers' perceptions, beliefs and classroom practices (Dewey, 1938; Mansour, 2009).

Superficial analysis of the initial interview conducted with Lenox revealed that he did not believe that learners' problems in electromagnetism was a cause for concern, since learners are not assessed on the topic at the matric level. From his statement and reaction, it seems that Lenox's beliefs about learners' problems in electromagnetism has a negative effect on his attitude in terms of teaching competency. This implies that there are some personal characteristics that may sometimes affect teachers' attitude in terms of competence (Blömeke & Delaney, 2012). However, a further inquiry into his classroom practice gave him the opportunity to review his personal classroom experience. The critical reflection on his learners' response to questions when teaching electromagnetism changed his beliefs about learners' difficulties in the topic. Martha revealed that the reflection phase of Lesson Study had changed her perception of the use of critical reflection in developing new teaching methods. She previously believed in re-teaching a lesson using explanation whenever learners seemed not to understand. However, engaging in Lesson Study changed her perception on how to teach certain lessons better. During her reflection on research lesson one she said:

Mr Alex's suggestion on allowing learners to observe, draw and discuss the magnetic field lines around the magnet made me realize that I could develop new ways of teaching the learners the same lesson if I take my time to critically reflect on the method I used in teaching the lesson before and not just re-teaching using the same method. (Martha, interview).

This implies that reflection is not only used to assess teachers' pedagogical practice in addressing learners' difficulties but also helps to gain an accurate understanding of how teachers' specific beliefs, attitudes and practice are connected (Abd Rahman, 2005).

Data obtained during the initial interview revealed that the four participants in this study have not attended any professional development training focused on physics as a subject. It seems this has a negative effect on their teaching practices. For instance, Mbali said:

We don't have any apparatus in my school and there is no subject adviser to help me out on other ways of teaching the practical to learners so I just verbally explain to them and continue with other aspects of the lesson. It's really hard for somebody like me but what can I do. (Mbali).

This was also mentioned in one of Alex's interviews when he said most professional training he has attended focused on chemistry and nothing on physics. Mbali and Lenox also indicated that they are left to address classroom problems on their own since they have not attended any form of professional development program in the last five years. This implies that the lack of opportunity to attend quality physics professional development programmes prevents physical sciences teachers from improving on their classroom practice. Data obtained during the initial interview clearly reveals that teachers' participation in professional development training have a significant impact on their classroom teaching practices, which involves the process of choosing lesson content, lesson delivery, inquiring about learners' difficulties and choosing the best teaching approaches.

During the final interview, Martha and Alex indicated that the lesson observation phase of Lesson Study had a positive influence on their learners' classroom behaviour in terms of their increased level of concentration and engagement in classroom lesson activities (see Section 5.12.1.1.4 and Appendix 18). Mbali mentioned that calling learners to solve problems on the board is time-consuming because learners are too slow to comprehend. However, she indicated that participating in Lesson Study improved her practice and awareness on the importance of calling learners to solve problems on the board. This was observed during her teaching on electromagnetism and Lenox's teaching on the electric circuit where learners were concentrating fully and actively participated in answering questions on the board (see Figure 4.8 and 4.11).

Nonetheless, when participants mentioned what they had learned while participating in Lesson Study, their responses revealed they were able to develop a better understanding and insights into knowing how learners learn. Participants acquired more knowledge about their learners. Lenox stated that the Lesson Study planning phase which involves anticipating learners' responses to questions asked in the class has helped him to be in tune with how his learners are likely to respond to and not respond to questions. He stated that anticipating learners' response to questions asked provided more information to him as a teacher when planning and teaching the lesson. Martha also mentioned that during their planning around magnetism, she realised that she could develop new ways of teaching the learners the same lesson if she takes her time to critically reflect on the method she used in teaching the lesson before and not just re-teaching using the same method. She developed a better understanding of how learners can learn magnetic field lines during their first planning meeting when Alex indicated that allowing learners to observe, draw and discuss the magnetic field lines around the magnet can make the teaching of magnetic fields effective for learners' understanding. These findings provide some evidence in support of Murata, Bofferding, Pothen, Taylor and Wischnia's (2012) investigation on how Lesson Study participants made sense of their learners learning, content and teaching. They stated that Lesson Study participants developed their knowledge of learners' learning through discussions around the planned research lesson.

In conclusion, participating in this Lesson Study intervention has helped participants to develop a more positive attitude towards creating an active learning environment, increased their willingness to take risks and try new teaching strategies. This finding is in line with findings in the literature which claims that participating in Lesson Study transforms participants' attitudes and beliefs towards achieving a desired change in instructional practices (Ebaeguin & Stephens, 2014; Pjanic, 2014).

6.3.4 Theme 4: Lesson Study experience

A final Lesson Study reflection on being a participant of this action research study was planned to be conducted with the Lesson Study pairs. Unfortunately, there were unforeseen circumstances at both Lesson Study locations due to learners' forthcoming examination. So, instead a one on one discussion with individual teachers was conducted about their experiences while participating in this Lesson Study. A representation of the subthemes characterised by participants' view on their Lesson Study experience is provided in Figure 6.4.

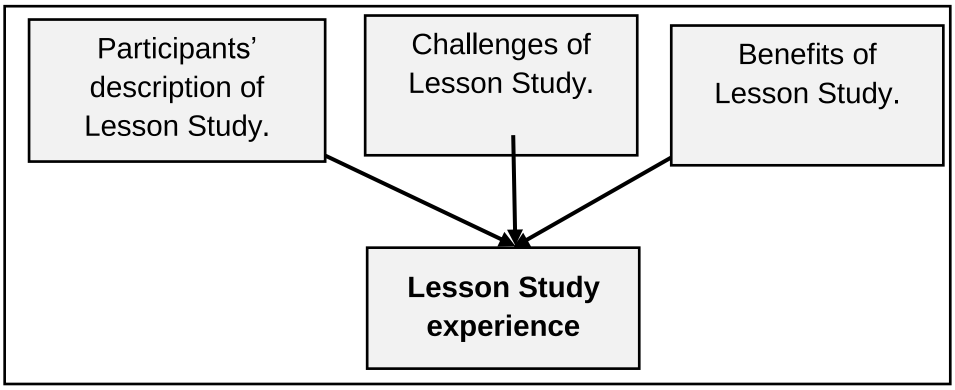


Figure 6-4: Lesson Study experience

The theoretical framework discussed in Chapter 2 points out that adults learn based on experience. Participants in this study expressed their interpretation of the Lesson Study process and considered new teaching strategies by reflecting on their experiences. Participants' reflection on their Lesson Study experiences was categorised into three major sub-themes which are participants' description of Lesson Study, challenges of Lesson Study and advantages of Lesson Study.

Researchers described Lesson Study as a classroom inquiry model which allows teachers to work together in small groups to jointly plan, teach, observe, analyse and refine classroom lessons to improve their teaching practice (Cerbin & Koop, 2006; Coe et al., 2010; Fernandez, 2002; Ono & Ferreira, 2010). When the teachers in this study reflected on their Lesson Study experience, they expressed their personal construction of Lesson Study. Participants' interpretation of the Lesson Study process was expressed as a motivating model focused on teachers' exceptional collaboration. Lenox, Alex, and Mbali described Lesson Study as an exceptional professional development training. Martha described Lesson Study as a professional workshop that supports teachers' collaborating to improve teaching pedagogy. Participants description of the Lesson Study process is in line with definitions in the literature summarising Lesson Study as a teacher professional growth model designed to improve the quality of teaching through teacher collaboration (Cerbin & Koop, 2006; Fernandez, 2002; Rock & Wilson, 2005; Stigler & Hiebert, 2009).

When participants in the study spoke about their most challenging aspect of the Lesson Study process, what they said was generally related to unavailability of time. Alex's perception on time as the most challenging aspect of Lesson Study was revealed when he said, "The whole phases involved is a little complicated and time consuming since it requires commitment and hard work like every teaching activity does". Lenox is a union representative who believes that he has too many responsibilities coupled with his teaching commitments. Lenox said, "Sitting together is a challenge because I am too busy to sit down and waste my time". It seems Lenox's comment on Lesson Study as a waste of time was based on his understanding of the amount of personal time that needed to be devoted to the Lesson Study sessions, since he has other responsibilities as a teacher and he is also appointed as a representative of the National Teachers Union. It may also mean that Lenox did not regard Lesson Study as useful. Mbali indicated that working together as teachers consumes a lot of time, this was observed when she said "the challenging aspect is sitting together to do this Lesson Study because we don't have that time at all." She attributed her unavailability of time to factors such as workload, job responsibilities, and family commitments. It was also observed that participants in this study found it very difficult to observe each other's classroom lesson due to their different teaching periods and different school locations for Lesson Study pair B. This was also indicated in Martha's post-interview response when she said:

> *"Remember you were explaining something on both of us observing each other's class; it's something I would have loved to do but it's quite challenging because I know that we teachers don't have the luxury of time on our side."*

This result agrees with Rock and Wilson's (2005) report which states that effective participation in the Lesson Study process requires participants' commitment and dedication of extensive time. Participants report on the unavailability of time as a challenging factor impacting participation in Lesson Study aligns with the results obtained from a study conducted by Yeap et al. (2015). During their investigation on the practice of the Lesson Study model in developing the professional development of Singapore teachers, results obtained in their study indicated that time factor was a major constraint affecting teachers' participation in Lesson Study. Lesson Study participants had great difficulty finding time to collaboratively meet, plan, engage in effective discussions and conduct classroom lesson observations. Another challenge that participants in this study encountered was designing a lesson plan during the collaborative planning meeting. It was observed that these teachers do not usually write a lesson plan in preparation for their teaching. So, writing a lesson plan during the Lesson Study planning meetings was difficult and challenging to all the participants (see Section 5.7.2 and Section 5.13.2.1).

In addition to the participants' reflection on their challenges experienced while participating in this study, they also talked about how participating in the study has contributed to the development of their professional knowledge and practice. They reported that collaborating in this study has improved their pedagogical knowledge and practice. Mbali said:

> *The interesting aspect of this is the group discussion because I was able to understand how to explain the direction of magnetic field on the board using my hand and problem-solving aspect on magnetic flux which my partner fully explained to my understanding because I was finding it a bit confusing. Mbali, interview).*

When participants shared their Lesson Study experience, they also reported an increase in learners' concentration and engagement in the teaching and learning process. Alex indicated that having an outsider in the class helped in creating a good environment for learners to show that they knew what they were doing. This was also observed in Martha's final interview response on the most important aspect of the whole Lesson Study process. She said, "Having an observer in the class actually made the learners more attentive". It seems that learners' increased level of attention could be attributed to learners performing for the video lessons recorded by the researcher. Participants also revealed what they had learned while participating in the study which was related to teacher learning. Lenox indicated participating in this study created an opportunity for him to make a quick judgment on what works best for his learners. He mentioned anticipating learners' response during joint lesson planning as what he learned while participating in the study.

Other benefits that were reported by the participants included an improvement in teachers' lesson introduction approach, change in teachers' belief about learners' application knowledge, a improvement in teachers' knowledge of lesson plan writing, improvement in classroom management skills, improvement in teachers' knowledge on how to assess learning, change in teachers' perception about individual learners' learning ability, opportunity to assess other teachers' knowledge of specific content during joint lesson planning, ability to focus on learners' observation and opportunities for teachers to observe each other's teaching. There is a confirmation of the benefits of Lesson Study as reported by research participants in the literature review. Rock and Wilson (2005) indicated that the collaborative and inquiry practice of Lesson Study help teachers to increase their pedagogical skills and content knowledge. Dudley (2013) confirms that the reflective and critical discourse analysis in filtering invisible tacit knowledge and replacing existing ideas with co-constructed knowledge through collaboration in Lesson Study help to improve teacher learning. This implies that the major advantage of teachers' participation in Lesson Study is centred on the theme of collaboration. One of the participants said, "I feel if I continue this practice with learned colleagues my understanding of some physics concept will change for the good". This statement confirms the report of the University of Philippines National Institute for Science and Mathematics Education Development on how to improve teacher effectiveness through Lesson Study (UP NISMED, 2013). They indicated that the benefits of Lesson Study cannot be fully acquired if the Lesson Study process was not continuously and regularly practiced as part of teachers' professional development training. This is because teachers have the natural tendency to return to their usual practice of teaching which they find more convenient and accustomed to.

6.3.5 Theme 5: Contextual factors and challenges

Despite the benefits attributed to participating in Lesson Study (Dudley, 2013; Lewis & Hurd, 2011; Rock & Wilson, 2005), there are contextual factors that influence the success and failure of using Lesson Study as a school-based professional development model (Adamson & Walker, 2011; Rock & Wilson, 2005; Saito & Atencio, 2013). The theme contextual factors and challenges reflect participants' views on potential factors that will affect their continuous use or practice of Lesson Study as physical sciences teachers. Figure 6.5 shows the five categories created under the theme contextual factors and challenges.

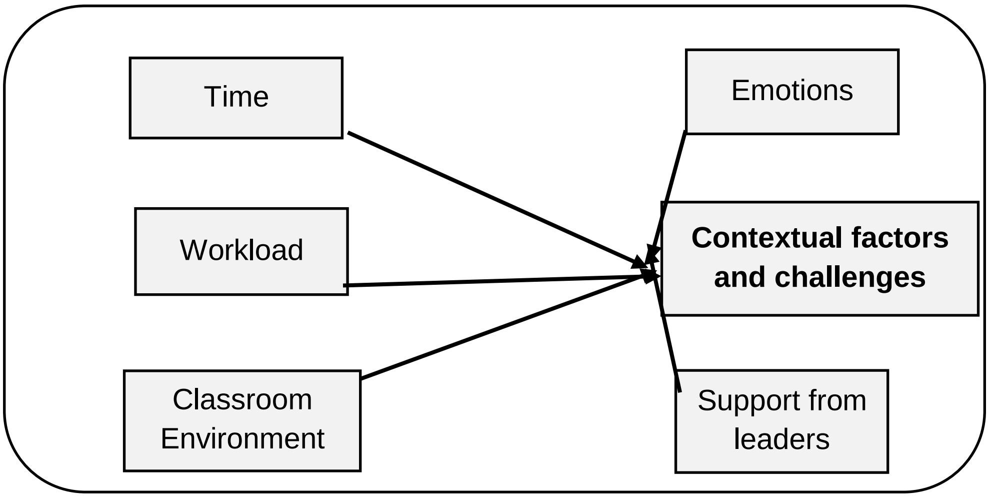


Figure 6-5: Contextual factors and challenges

All four participants in this study reported unavailability of time due to workload and teaching responsibilities as contextual factors that will influence their continuous practice of Lesson Study. Lenox's explanation of unavailability of time was attributed to curriculum overload and a shortage number of physical sciences teachers. He said:

> *"Obviously.... time factor because the curriculum is loaded and we have few physical sciences teachers in school so it's difficult telling me to sit and plan a lesson with other teachers."*

Martha's reflection on the unavailability of time was attributed to learners' difficulties and their negative attitudes towards physical sciences lessons. She said, "I think time is the main factor because our learners struggle with the learning pace in physical sciences". Akiba and Wilkinson (2016) mentioned teachers' work schedules as one of the major challenges that do not give teachers enough time to effectively participate in the continuous practice of professional development programmes such as Lesson

Study in the United States. A teacher’s work schedule is not restricted to the planned sequence of lesson content to be covered by the teacher, but also involves job responsibilities in terms of the teaching period, number of classes and number of subjects the teacher is to teach. Participants in this study reported spending an average of 33.25 hours per week on teaching. The reported teaching period per week is higher compared to the average teaching period of 27 hours per week reported by American teachers and 19 hours per week by other nations that took part in the 2013 Teaching and Learning International Survey (TALIS). The 2013 TALIS result indicated that teachers in Japan tended to report a higher participation rate in professional development since they spend an average of 18 hours per week teaching and nine hours for planning their lessons (Organisation for Economic Co-operation and Development (OECD, 2014)). Overall, it appears that the reason why Lesson Study works in Japan is that teachers spend less time on teaching and more time on improving their practice through collaborative planning and analysis of learners’ learning.

In addition to participants’ views on the unavailability of time, they also talked about their fear of being criticised by colleagues as a contextual factor that will possibly influence their continuous practice of Lesson Study. Mbali believes that the analytic reflection phase of the Lesson Study process could result in a nasty and ugly criticism of the observed teacher’s lesson. She said:

> *“This cannot work because some of our colleagues will over criticize your approach and turn you down, this can demoralize you as a teacher if you are not confident of yourself.”*

Mbali’s response reveals that some teachers are accustomed to teaching in isolation, so opening their classroom to other teachers for constructive criticism becomes a great challenge and threat. This implies that establishing effective collaboration among Lesson Study participants could be very challenging and messy when participants see it as a problem to give effective critique about each other’s lesson (Adamson & Walker, 2011; Rock & Wilson, 2005). It is possible that issues concerning constructive criticism as a corrective feedback should be discussed during planning session to avoid messy situations.

Mbali and Lenox expressed their views on how factors related to the classroom environment could affect their continued practice of the Lesson Study process. This was observed when Mbali indicated that “using several teaching methods in a class where the learning difficulty of learners varies may not allow this method to work effectively”**.** Lenox indicated that “the collaborative lesson planning phase of Lesson Study is quite impossible and can never work because we have different school or classroom situations and different learners”. It seems that lesson study pair A is concerned about the challenges involved in developing new strategies suitable to address the different needs and abilities of learners in their classrooms.

Participants also talked about the lack of support from school leaders, unions, district offices and department of education as that could hinder their participation and continuous practice of the Lesson Study process. Mbali indicated that school principals believe in teachers going to class to teach. So, giving teachers opportunities during school hours to collaborate becomes a problem. Lenox’s response to contextual factors also revealed that he was concerned about the attitude of school leaders towards teachers’ participation in school-based professional development programmes that were not organised by the department. Lenox mentioned that school principals always wanted teachers in class and seeing teachers gather together may be interpreted that teachers were not doing their job. The issue of teacher absenteeism has been a major concern attributed to the low provision of quality education in South Africa (Reddy et al., 2010). So, it is possible that principals have been requested to address teacher absenteeism and ensure that teachers teach their scheduled lessons. Lenox went further to explain how school principals see teachers as threats trying to dictate or take over their position when suggesting programmes like this to the district office without the principal’s awareness. He also indicated lack of support from union as a concern. This was observed when he said “remember these association people did not even encourage us as teachers to use the lesson plan”. Alex, on the other hand, believes that most effective professional development workshops are not presented by the department but external providers. So, teachers find it difficult to participate in professional workshops organised by external providers since they are neither handled by the department nor supported by the school. Research claims that the direct support and commitment of school principals, school district officials and the Department of Education plays a major role in enhancing teachers’ effective participation and practice of Lesson Study at the local capacity (Aiello & Watson, 2010; Akiba & Wilkinson, 2016). However, OECD (2014) indicated that support from educational stakeholders could be in terms of scheduled time for teachers' participation in professional development training, negotiate financial support in terms of a salary supplement for participating in such activities and non-monetary support like reduced teaching time, days off, study leave etc. The successful implementation of Lesson Study as a teacher professional development programme in Japan was attributed to the support obtained from their culture of positive attitude to work (Ebaeguin & Stephens, 2014; Pjanic, 2014). This implies that factors affecting teachers' participation in Lesson Study can become less challenging if school leaders, the school district and the department of education work together to improve organisational structures and routines, develop new policies and allocate funds to support teachers' continuous practice of the Lesson Study process within their cultural context (Akiba & Wilkinson, 2016).

When participants spoke about contextual factors, they also reflected on how the interest of teachers and the support of various educational stakeholders could affect their effective engagement and continuous practice of the Lesson Study process. Martha mentioned that many teachers might not be interested in participating in Lesson Study because "we sometimes see everything like additional burden on us". This was also reflected in Alex's views when he said that the successful implementation of Lesson Study as a continuous practice solely depended on the teachers' interest and voluntary participation. It is possible that the low number of physical science teachers in a school may also have a negative influence on teachers' personal interest and participation in Lesson Study. In the same way, it is believed that teachers' interest in the form of motivation for choosing the profession can positively or negatively affect teachers' competence, as revealed in this study. For instance, Lenox indicated that he was never interested in teaching. However, he aspires to a leadership position in order to remain in the profession. It is possible that providing leadership opportunities through engaging in professional development programmes could develop the interest and commitment of teachers in the profession. The researcher understands that the teachers' passion and commitment to the Lesson Study process is greatly dependent on the kind of support they receive to participate in such a professional development programme (OECD, 2014). However, the success of Lesson Study is highly dependent on teachers' support since teachers have the tendency of modifying policies that are not beneficial to their practice.

In conclusion, the practical challenges facing teachers' participation in Lesson Study are the shortage of physical sciences teachers, work load, unions and insufficient instructional materials.

6.4 Revisiting the research questions

Based on the rationale that some teachers still use traditional teaching strategies since they were taught by this method, it was decided to explore physical sciences teachers' views and behaviours as they progressed in teaching electricity and magnetism during a Lesson Study intervention. To do so, the following main research question was formulated:

> How does the Lesson Study process affect the teaching of electricity and magnetism?

To address this main question, the following sub-questions guided my inquiry:

- How does Lesson Study influence teachers' knowledge about teaching electricity and magnetism?
- How does Lesson Study influence teachers' attitudes and beliefs towards teaching electricity and magnetism?
- What are the contextual factors affecting teachers' participation in the Lesson Study process?

Main question: How does the Lesson Study process affect the teaching of electricity and magnetism?

Details of the Lesson Study cycle adapted in this study has been discussed in Section 3.6 (Figure 3.2 and 3.3). Participants in this study were engaged in three teaching cycles, using only one cycle per topic. Each cycle had three stages of preparation, teaching and reflection of research lessons as illustrated in Figure 6.6. Participants used suggestions from post reflection on research lesson one to improve their planning for research lesson two and the cycle continued as the process was repeated for research lesson three.

Sampled teachers in this study used the joint planning, teaching and reflection phase of the Lesson Study process to improve the teaching and learning of electricity and magnetism in their respective classrooms. Participants were unable to observe each other's classroom lesson presentation but they observed and reflected using the recorded videos of lessons. In order to understand the experiences of these teachers while participating in this study, this research began with questions designed to give insight into sampled teachers' attitude, beliefs and knowledge in teaching electricity and magnetism before, during and after participating in this study; as well as factors affecting teachers' effective participation in the Lesson Study process.

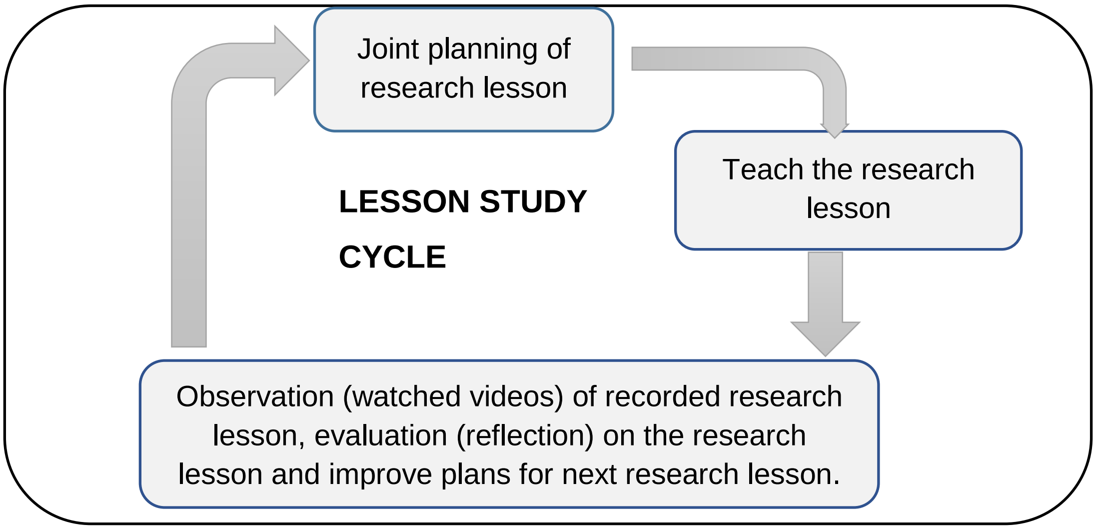


Figure 6-6: Lesson Study cycle

6.4.1 How does Lesson Study influence teachers' knowledge about teaching electricity and magnetism?

Teachers' knowledge is one of the intervening variables used to explain the theoretical framework underpinning this study. To answer this question, participants' reflections on their knowledge (knowledge on learners' difficulties, content knowledge and pedagogical knowledge) during the interviews and Lesson Study pair reflection meetings were analysed. For clarity in answering this question, the researcher reiterates what has been discussed in the theoretical framework (Section 2.6.1 and 2.6.2), namely that participants as adult learners tends to be motivated to seek, evaluate and improve on tasks when they socially collaborated with other people. This social interaction gives participants the opportunity to construct new knowledge.

Participants in this study indicated that working together created an avenue for teachers to support one another through sharing their experiences, knowledge, identifying individual strengths and weakness, exchanging ideas, getting feedback from professional experts and discussing and developing new teaching skills. During the initial interview and Lesson Study planning meetings, participants demonstrated their knowledge through their discussion and reflection on learners' difficulties in the electricity and magnetism. All four participants reported that learners generally struggle with concepts in electric circuits. Mbali and Martha believe that learners' difficulties on the electric circuit are based on their lack of mathematical skills. On the other hand, Alex and Lenox seem to be concerned about learners' difficulty in understanding electric circuit concepts. All four participants also agreed that Grade 11 learners struggle with the concept of electromagnetism. During participants' reflection on learners' difficulties, Lenox and Alex identified the energy theorem and generators as difficult topics peculiar to Grade 12 learners. Participants' reflection on learners' difficulties during the interview is provided in the Appendices (13A, 13B, 18A, and 18B). Participants' views about learners' difficulties in electricity and magnetism are in line with findings reviewed in the literature which suggest that learners have problems with the application of Faraday's law, the meaning of change in magnetic flux, inability to simplify complex circuits and correctly state Ohm's law (DBE, 2015; Hieggelke et al., 2001; Koudelkova & Dvorak, 2014; Miokovic et al., 2012; Planinic, 2006; Raduta, 2005; Saglam & Millar, 2006). However, the Lesson Study planning meetings gave participants the opportunity to discuss their knowledge and experiences about learners' difficulties in electricity and magnetism, as observed during the initial interview and planning meetings. The planning phase of this Lesson Study intervention improved participants' views about learners' difficulties in electricity and magnetism. For instance, Lenox had previously believed that learners did not t have difficulties in electromagnetism, but the collaboration phase of this intervention programme changed this perception. Nevertheless, all four participants indicated during the interview that they themselves also struggled with concepts and knowledge on electromagnetism as their learners did. It is possible that participants have some foundational knowledge required in teaching physical sciences as a subject, however, their content knowledge was not always adequate. This implies that teachers' knowledge gaps were not necessarily discussed in this study, since participants don't know the content knowledge well enough to notice and address gaps during the Lesson Study meetings. A summary of sampled teachers' knowledge of learners' difficulties in electricity and magnetism as reported in this study is shown in Figure 6.7 below.

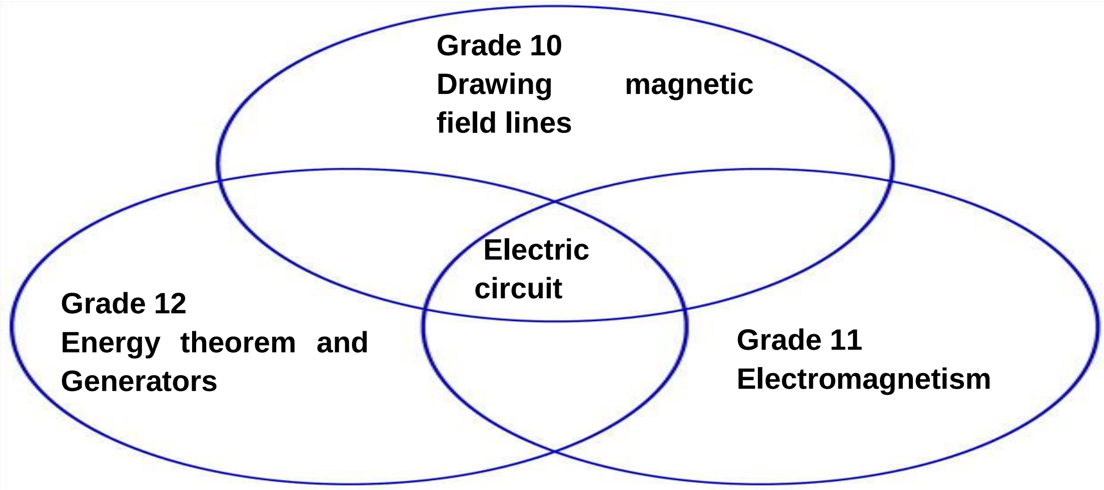


Figure 6-7: Teachers' views about learners' difficulties as reported in this study

Working together in this Lesson Study intervention gave participants the opportunity to use their discussions on learners' difficulties to improve their teaching strategies. For instance, Martha reflected on how working together with another teacher in this study improved her knowledge about effective practical demonstrations for teaching magnetic field lines. This implies that participating in this study improved Martha's ability to perform inquiry based practical activities to enhance learners' understanding. Her reflection is supported by her discussion about magnetic field lines during the Lesson Study pair B's planning and reflection meeting (see Section 5.5 and Section 5.7.1). This implies that teacher collaboration during Lesson Study help participants to accept most of the ideas obtained through reflection on their personal actual practice and that of their colleague as reported by Saito and Atencio (2013).

Working together with the provided lesson planning template also influenced Alex and Martha's knowledge of lesson plan writing; even though they had indicated that lesson plan writing was a challenging experience for them. It was found that the Lesson Study meetings gave teachers the opportunity to develop their knowledge of lesson plan writing as they shared responsibilities among themselves while participating in this research study. Lesson plans submitted by each Lesson Study pair after participation in this study showed an improvement from the original lesson plans presented during the initial interview (see Appendix 15 and 17). Nonetheless, it was observed that Lenox still finds it difficult to use some vocabulary appropriately in the final lesson plans.

The discussion process based on classroom observation also changed Alex's knowledge and belief on the importance of using daily life experiences to relate his lessons and stimulate learners' interest (see Section 5.12.1). Thus, the findings support the view that Lesson Study participants develop other forms of pedagogical content knowledge which replace their existing ideas and strong beliefs about their teaching practices (Dudley, 2013; Stols & Ono, 2016). Lenox also stated that the collaboration aspect of Lesson Study improved his teaching skills and he learned a new approach to teaching some concepts. Though he did not specify the new approach he used during his lesson presentations, it was observed that Lenox used problem solving as the starting point for his teaching in lessons two and three and provided flexible guidance to learners, thereby promoting learners' engagement in the teaching and learning process. This was not mentioned as his teaching strategies prior to participating in the study, and is explained as new knowledge developed during Lesson Study. Participants reports on the outcome of collaborating while participating in this study supports Dudley's (2013) results which attributed the improvement in teachers' knowledge, skills and practice due to participation in the Lesson Study activity. The joint activities in this study enabled participants to reflect on their experiences and develop new knowledge for their teaching practices.

Teachers' self-efficacy in terms of confidence levels is an important factor that influences learners' academic outcomes (OECD, 2014). Participants in my study reported how working together has influenced their professional network, improved their level of self-efficacy and classroom management skills. During the interview, Mbali and Lenox indicated how working together as teachers in the same school influenced their ability to manage instructions and take up instructional risks together.

Mbali said, “This collaboration process has really helped me to build a working and friendly relationship with my colleague and you know this tends to have a way of helping me to gradually reduce this habit of planning and teaching in isolation”. The Teaching and Learning International Survey conducted by the Organisation for Economic Co-operation and Development (OECD) points out that teachers collaborate more with their colleagues when professional development activities afford them the opportunity to network with each other to provide mentoring and coaching. This implies that engaging in this Lesson Study intervention has helped the participants to build collegial support for one another and also increased their confidence to apply new knowledge as they explored new instructional ideas (Lewis & Hurd, 2011; Rock & Wilson, 2005; Stols & Ono, 2016). Though Lesson Study improved teachers’ knowledge, it can be argued that Lesson Study remains ineffective where there is gap in teachers’ content knowledge.

6.4.2 How does Lesson Study influence teachers’ attitudes and beliefs towards teaching electricity and magnetism?

To explore the effect of teachers’ participation in this study on their beliefs, attitudes and classroom practices, teachers’ classroom lesson observations, reflection on Lesson Study experience as well as interview responses were analysed. Participants in this study were observed during the Lesson Study pair planning and presentation of research lessons to learners. Prior to the commencement of this study, participants’ response towards reflection on learners’ difficulties indicated that all four participants had a negative attitude towards reflection. However, two of the participants indicated how participating in this study changed their reflection level. During the pre-interview, Martha indicated that she reflected on her class teaching whenever she had the feeling that learners did not understand her lesson and she then re-explained it. However, participating in this study, Martha developed new strategies and improved on her reflective practice (see Figure 5.3.2). Previously, Martha engaged in an empathetic-reflection based on emotions but participating in this study improved her reflection level. She engaged in a relational reflection which followed a dialogue between her and Alex during their lesson planning on the first research lesson. This dialogic reflection improved Martha’s pedagogical knowledge while teaching the research lesson on magnetic field lines. This was confirmed during the post interview when she said:

I do my reflection whenever I have this feeling that I had a bad lesson and I just go back to re-explain the lesson again but during our first meeting, Mr Alex's suggestion on the idea of allowing learners to observe, draw and discuss the magnetic field lines around the magnet made me realize that I could develop new methods of teaching the same lesson if I take my time to critically reflect on the previous method used. (Martha, interview).

Mbali indicated that she enjoyed the aspect of reflecting on her learners' response. This was evident in her statement when said:

I just teach based on the curriculum and what they want us to teach but one captivating thing is the ability to think about what I want my learners to know while teaching the lesson. I was able to see the importance of that thinking because a lot of critical issues was raised and I was able to know why the topic should be taught and how to teach it to the learners. (Mbali, interview).

She previously reflected based on the curriculum but participating in this study improved her knowledge on how to reflect based on learners' response. This implies that participating in Lesson Study could help teachers develop their reflective practice through critical examination of their beliefs and attitudes towards teaching. This finding supports the view of Rock and Wilson (2005) which states that Lesson Study improves teachers' reflective practice.

Three of the four participants also reported improvement in learners' outcome and increased teachers' awareness of different evaluation approaches. Alex claimed that the classroom observation phase influenced learners' attitude and behaviour during the teaching. This was observed when he said, "I think your presence (researcher) in the class made the learners attentive and respond well to my question". He also believed that having an outsider as an observer helped him identify the gaps between his teaching method, teaching approach and his learners' understanding. Lenox also indicated how the observation phase of Lesson Study influenced his understanding of learners learning. He said:

I was able to observe a particular learner over the entire lesson and I tried understanding how this learner thinks whenever I ask him to answer a question

> *in the class. This is something I have never done with any of the learners before and I think this is a good method. (Lenox, interview).*

Lenox's interest in trying to understand learners' learning could be ascribed to a change in attitude developed during Lesson Study. The various stages involved in the Lesson Study process enhanced teachers' ability to predict learners' response to questions and prepare effective methods to address wrong answers. This was evident in Lenox's statement when he said:

> *This aspect of planning where you anticipate learners' response to questions asked in the class has actually helped me to be in tune with what the learners are likely to respond to and not respond to. And you know .... Eeem this provides more information to me as a teacher when planning and teaching the lesson. (Lenox, interview).*

During the interview, Mbali also mentioned that she used information obtained from the planning sessions to apply new knowledge and teaching practice in her classroom. This classroom teaching practice included the use of classroom discussions and calling learners to solve problems on the board.

This study also considered each participant's classroom practice based on their observed lesson presentation. Lenox previously instructed his learners on what to do when teaching electricity, involved learners in practical activities when apparatus was available and used various solved examples when teaching. However, participating in this study, he was able to improve his practice by improving learners understanding of the lesson taught through learners paired activities. This was observed during his lesson presentation on the electric circuit when he actively engaged all learners in the teaching process by allowing them to individually solve problems and share their answers with one another (see Section 4.11.1) rather than simply instructing them on what to do. Mbali previously used explanation, solved class activities and motivated learners to solve questions when teaching. However, participating in Lesson Study, she was able to improve on her teaching technique by engaging learners in an effective classroom discussion. During Mbali's observed lesson on electromagnetism, she encouraged learners to explain and justify their understanding of the scientific concept that was taught among themselves. This was observed when she allowed learners to draw, demonstrate and explain the right-hand rule concept as they listened and questioned each other's explanation (see Section 4.9.2). It seems that Mbali actively engaged learners in this lesson to assess their thinking level and foster a sense of proficiency among them. During Alex and Martha's lesson planning and presentation on magnetic field lines, both teachers reflected on how their learners' understanding and interest was stimulated. This was observed when both teachers asked their learners to observe, draw, explain and compare their observation of the practical demonstration on the different magnetic field lines as diagrams in their textbooks (see Section 5.6 and Section 5.7.1). It was found that all four participants became more practical in their approach to teaching as proposed in the theory of andragogy (Knowles, 1980). The obtained data showed that participating in Lesson Study positively improved teachers' attitude towards their practice in teaching electricity and magnetism.

Two of the four participants did not implement the practical activities required for teaching research lesson three (electric circuits) as planned during the Lesson Study meeting (see Section 4.10.2; 5.10.2). Martha had initially planned to conduct the practical experiment with learners as indicated in her lesson introduction in Section 5.11.2. However, this was not observed during her teaching. During her lesson presentation, she said:

> *"We might not be able to do the practical experiment as mentioned in the beginning of the class because of your exam so you will be given values to work with for your practical cycle".*

Learners were unable to perform the required experiment since they were about to write their second term examination and the teachers had not covered the required lesson content yet. However, it was not clear whether Martha really intended to do the practical. During Lenox's lesson presentation on research lesson three, it was observed that Lenox did not conduct the practical activity as planned during the Lesson Study meeting. Prior to participating in this study, he indicated practical activity as one of his teaching strategies when he said, "I try as much as possible to do practical activities whenever apparatus is available". However, this was not observed in any of his lessons as compared to other participants who engaged learners in practical activities and demonstrations during their teaching. It seems that Lenox did not have adequate skills and the confidence required to conduct practical activities.

This implies that Lesson Study did not improve teachers' attitudes towards practical work and laboratory practice as planned.

The analysis of data gathered during the pre-interview suggested that Lenox had an entrenched belief about learners' difficulties in electromagnetism. This belief emanated from his experience as an examiner. He said, "When we moderate for marking, we hardly consider electromagnetism as a difficult topic because learners are not assessed on that topic at the matric level". This indicated that Lenox had a distorted view of what difficulty meant. His response did not show concern that learners understood electromagnetism, but rather suggested that learners did not needed to understand the topic. This belief clearly influenced his teaching attitude, suggesting that he was more interested in examination results than in his learners' understanding (see Appendix 13A). This result supports the view that teachers' beliefs greatly influence their teaching attitudes and classroom practices (Ernest, 1989; Mansour, 2009). However, the theoretical framework discussed in Section 2.6.1 stresses the fact that active engagement in social interaction with others and individual interpretation of personal experiences may change teachers' attitudes, beliefs, and practices. It was found out that probing further into Lenox's personal classroom experience as a teacher and participating in Lesson Study changed his view about learners' difficulties in electromagnetism (see Appendix 13A), and he was also enthusiastic when teaching the concept of induction.

During classroom observation, the two participants that focused on Grade 11 lessons showed confidence in teaching electromagnetism after participating in this study (see Section 4.9.1 and 4.9.2). Mbali feels that collaborating with her colleague improved her knowledge and confidence on how to teach the direction of the magnetic field using demonstration and problem solving on magnetic flux. She said "working together with you people have helped me to a greater extent in bringing down this wall I have built around myself whenever am teaching this electromagnetism". This was observed when she walked around the class as she used her hands to explain and demonstrate the concept of "in page" and "out of the page" to the learners. She also calmly and confidently explained the concept after learners were called out to demonstrate on the board. Lenox also indicated that a teacher can be teaching for many years and still not have confidence teaching specific topics. He believes that the Lesson Study planning and reflection phase increased his confidence level. This was evident when he said" I have a feeling that I am beginning to build my own self-confidence in some aspects of this physics concept and I will say that this Lesson Study training has positively affected my method to learning some physics concept by allowing me to visualise physical sciences in a more practical way than before". The ability to work together, reflect and discuss on observed lessons during this study helped my participants to examine their own understanding and improve their classroom teaching with a focus on enhancing learners' conceptual understanding. The results obtained from my participants' reflections and observed lessons confirm Rock and Wilson (2005) result which indicates that the collaborative and focused reflective nature of Lesson Study have a lasting impact on participants classroom practices.

In summary, findings of this study indicate that participants' attitudes towards their classroom teaching was improved through their increased confidence level, increased level of reflection, improved pedagogical knowledge and skills. However, their informed attitudes did not always lead to conducting practical activities during lesson.

6.4.3 What are the contextual factors affecting teachers' participation in the Lesson Study process?

To establish teachers' views on possible contextual factors that might affect their continued practice of the Lesson Study process, participants' reflections during interview and Lesson Study meetings were analysed, as provided in Chapters 4 and 5. Contextual factors that emanated from participants' reflections include:

- Unavailability of time.
- Fear of being criticised.
- Diverse learners' challenges in different classrooms
- No adequate plan and financial budget from school.
- Low numbers of physical sciences teachers in schools inhibits cooperation.
- Professional responsibilities and curriculum overload.
- Teachers' lack of interest and attitude towards professional development.
- Lack of specialised teachers, professional experts or subject advisers.
- Lack of support from the district and provincial education department.

- Lack of support from school leadership.

Though Lesson Study combines several desired elements for an effective professional development programme, there are numerous challenges and contextual factors associated with the successful and sustainable implementation of the model as discussed in the literature review.

All four participants in this study reported unavailability of time as a contextual factor. Time constraint is one of the commonly cited challenges that limits teachers' continuous practice and effective participation in Lesson Study (Lewis & Hurd, 2011; Yeap et al., 2015). During the data collection, it was observed that participants from Lesson Study pair A, in the same school had different teaching periods and responsibilities, so they struggled with finding a common time to effectively meet, observe each other's classroom lessons and engage in discussions. The Lesson Study process is considered to be time-consuming (Fernandez, 2002) and not accommodated into teachers' usual work plan. It appears that the sampled teachers considered their participation in this study as an additional responsibility to their professional duties since specific time was not allocated in their daily or weekly schedule for participation in professional development programmes. Participants' reflection on the unavailability of time could also be attributed to their workload, curriculum content, small number of physical sciences teachers in a school and other professional responsibilities. This was observed when Lenox said, "Obviously.... time factor because the curriculum is loaded and we have few physical sciences teachers in school so it's difficult telling me to sit and plan a lesson with other teachers". Mbali indicated that the workload in the school is too much since there are many physical sciences learners across technical, science and commercial stream. She also needs to plan for the additional subject she teaches.

Mbali expressed her thought on fear of being criticised when she said, "Another reason why I said this cannot work is that some of our colleagues will over criticise your approach and turn you down, this can demoralise you as a teacher if you are not confident of yourself". It seems Mbali was very concerned about the effect of constructive criticism on her identity. This concern has also been documented in the literature, unequal power relations among Lesson Study members could contribute to participants' fear of being observed and criticised by peers. Such peer criticism could lead to mistrust and lack of respect among Lesson Study participants.

Similarly, all participants reported lack of support as another contextual factor that could obstruct teachers' continuous practice of the Lesson Study process. Participants' reflection on support was reported in various domains. For instance, participants mentioned the lack of a financial budget and support from the education department as a contextual factor. Research points out that the sustainable execution and maintenance of teachers' participation in Lesson Study are dependent on the nature of their funding, government policies and organisational structures (Akiba & Wilkinson, 2016; Piercey, 2010; Rock & Wilson, 2005). This implies that the departments of education need to create new policies, routine and practices within existing organisational structures to promote teachers' continuous participation and practice of Lesson Study.

Two of the participants also mentioned lack of support from school principals and teacher unions as another contextual factor. Lenox mentioned that the union did not encourage them as teachers to use lesson plans. Mbali indicated that the collaborative lesson planning might be impossible due to learners' diverse academic needs and challenges across different classrooms and schools. She also mentioned that principals will obstruct Lesson Study since they believe that teachers should be in class and would find it difficult to give teachers time during the week to departmentally collaborate. Ngang and Sam (2015) emphasise support from school leaders as a key factor that would promote the successful implementation of Lesson Study as a school-based approach. They further elaborated on the role of school leaders to include: 1) \Providing support for learners learning by ensuring that teachers use effective teaching strategies; 2) Serving as initiator, director and promoter of quality school-based programs that can enhance teachers' classroom practices.

Participants also reported lack of specialised physics teachers, professional experts or subject advisers as a contextual factor. However, Martha and Alex indicated how the researcher's presence during classroom observations influenced their learners' learning (see Section 5.12.1.3 and Section 5.12.2.1). Thus, the finding is in accordance with the view that the inclusion of an outsider such as a specialist teacher or professional experts serves as a critical support in helping Lesson Study participants maintain focus on learners' learning, teacher development and the successful implementation of Lesson Study across schools (Lewis & Hurd, 2011; Rock&Wilson, 2005).

Martha and Alex's reflection on contextual factors also revealed that teachers' interest and commitment to professional development could be a possible hindrance to teachers' continued practice of the Lesson Study process. This finding is in accordance with the view that teachers' willingness, readiness and commitment are important attitudes to be considered for continuous and effective participation in professional development programmes (Akiba & Wilkinson, 2016; Knowles, 1980).

The Andragogy theory discussed in Section 2.6.2 lays emphasis on principles guiding teachers' effective participation in professional development programmes. This theory stresses the fact that learning occurs through continuous participation in learning opportunities provided within the work environment. The theory also philosophises that participation in professional development is based on teachers' readiness to learn, relevance, self-concept, orientation to learning, experience and motivation to learn. These principles were used as a guide throughout the Lesson Study intervention. However, the andragogy theory was used to summarise participants' responses about contextual factors into three major categories namely work environment factor, personal factor and task factor as portrayed in Figure 6.8.

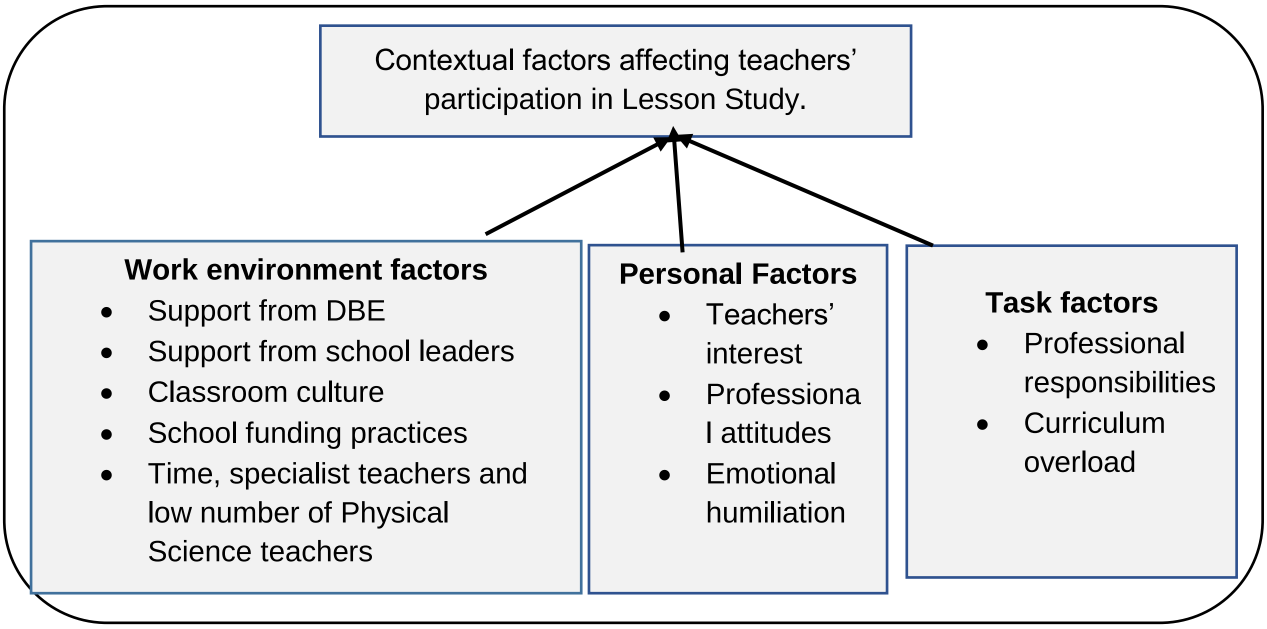


Figure 6-8: Categories of contextual factors affecting teachers' effective participation in Lesson Study as reported by this study.

6.4.4 Summary of answers to research questions

A summary of the results obtained to verify the research questions underpinning this studyare provided in Table 6.1.

Table 6-1: Summary of answers to research questions

	Questions	Answers
Main - Question	How do physical sciences teachers use the Lesson Study process to enhance the teaching of electricity and magnetism?	Teachers in this study used the joint planning, teaching and reflection phase of the Lesson Study process to improve the learning and teaching of electricity and magnetism in their respective classrooms. Evidence of improvement in teachers' knowledge, skills, attitudes and beliefs during these stages are reported in the sub-questions.
Sub – Research Questions	1) How does Lesson Study influence teachers' knowledge about teaching electricity and magnetism?	Working together during Lesson Study increased teachers' confidence level when teaching electromagnetism. It also improved teachers' inquiry and teaching skills, and understanding of specific concepts as compared to what was said during the initial interview. Martha previously expected learners to only observe a practical demonstration, but collaboration during Lesson Study improved her practical knowledge on how to effectively engage learners in the practical demonstration of magnetic field lines using other methods. Collaboration during Lesson Study also fostered teachers' willingness to take an instructional risk and manage instruction together. Previously, Alex did not relate his lessons using real-life situations but collaborating during Lesson Study increased his awareness of the importance of using real-life challenges in stimulating

		learners' interest in a lesson. Collaboration in Lesson Study enabled teachers to engage in a critical discussion focused on learners' problems, thereby building a professional working relationship with colleagues in the same school and from outside the school. Lesson Study improved teachers' awareness about learners' difficulties in electricity and magnetism. It also enables teachers to gradually reduce the habit of planning and teaching in isolation. Teachers increased knowledge also changed their attitudes to learners.
	2). How does Lesson Study influence teachers' attitudes and beliefs towards teaching electricity and magnetism?	One of the teachers previously believed that learners already knew the application of science concepts in their environment, so he taughtthe theoretical knowledge of the lesson without linking it to everyday life. However, participating in Lesson Study changed his perception and belief about his teaching practice. Participants also reported that Lesson Study improved their beliefs on how learners learn through critical reflection and anticipation of learners' response. Teachers could identify the gaps between learners' understanding of a lesson and their method of teaching. Teachers also experienced a changed attitude towards their pedagogical practice. Two of the four teachers used more of a learner-centred approach by calling learners to solve problems on the board, which was not indicated in their teaching approach prior to participating in this study. Based on lesson observations, all participants engaged learners in classroom discussion through teacher direct question and answer, and learners led discussions which were not mentioned as a teaching method before participating in this study. Participating in Lesson Study improved teachers' confidence level when teaching. One of the teachers indicated how she used to avoid learners' questions whenever she was teaching electromagnetism. However participating in this study, she confidently moved around the class explaining the concept of "in-page" and "out of page" using information provided during the Lesson Study planning meeting and provided correct feedback to learners' questions during the observed lesson.
	3) What are the contextual factors affecting teachers' continued practice of the Lesson Study process?	Teachers found it difficult to effectively participate in this study as expected due to the difference in location of schools and teaching periods. However, their willingness and availability to participate within the restricted time proved to have a positive influence on their professional knowledge, beliefs, attitudes and classroom practice. Teachers regarded the Lesson Study process as time-consuming since they all had a full schedule, so finding time to effectively participate in such programmes became a problem. Lack of support in terms of funding and policy within the organizational structure is likely to affect teachers' continuous practice and participation in Lesson Study. All participants reflected on the absence of subject advisers, no budget plan for participation in professional development and attitude of stakeholders such as school leaders, union leaders, district and provincial education department

		towards participation in quality professional development programs. Teachers' self-efficacy and confidence level also seem to be possible factor that may hinder their continuous participation in Lesson Study. One teacher reflected on her fear of being criticised by colleagues since she still struggles when teaching specific topics like electromagnetism. She believes that the lesson critique phase involved in Lesson Study could be demoralising to her as a teacher. Teachers also reported different classroom environments, low number of physical sciences teachers in schools, teachers' interest and attitude towards professional development and possible contextual factors.

6.5 Researcher's reflections

During this study, I engaged with four physical sciences teachers who willingly participated in this study and gave me access to their classrooms as they shared some of their knowledge, challenges, and experiences while participating in the study with me. Though I may have misinterpreted data unknowingly, I constantly reminded myself to be objective. I strived to ensure the credibility of this study through methodological triangulation by using interviews, three different lesson observations per teacher and teachers' reflective writings as multiple sources of data. To further improve the trustworthiness of my research study, I sought the assistance of two peer researchers as critical friends during the coding process. I also held consensus discussions with my supervisor to check my data interpretation, and corroborated my findings with findings reviewed in the literature.

To minimise situations where participants would put up their best act during their classroom teaching and Lesson Study meeting due to their awareness of being observed, I requested the teachers to be natural when teaching. I also emphasised the fact that the research was not to report them to the authorities but rather to have a better knowledge of how participants used the Lesson Study model. This assisted me during the interview since the participants could express themselves without any reservation.

As a researcher and an experienced physics teacher, I learnt much during this research study. My understanding of professional training for teachers grew from the understanding of attending teachers' conferences, seminars, and workshops to a practical form of training using real classroom situations. I learned about some teacher-related factors that hinder learners' understanding of specific physics topics like electromagnetism. I also learned about what teachers go through when dealing with promotion criteria for learners.

At the beginning of my study, my original plan was to invite physical sciences teachers teaching the same grade level (Grade 11) from neighbouring schools to participate in this study. Unfortunately, the majority of the teachers I approached were not willing to avail themselves of this study since they claimed they were too busy. For those who were interested, the schools were too far apart to arrange meetings. Some teachers I met also refused participating in this study when I informed them that I would be video recording their classroom teaching. Since the available teachers that participated in my study in 2016 were two teachers from the same school teaching the same grade level (eleven), it gave me the opportunity to use my study as a school-based professional development programme for these two teachers working as a Lesson Study pair. Due to the small number of participants, I had to conduct the research with another set of participants in the following year (2017). Unfortunately, most schools I contacted the following year had only one physical sciences teacher teaching across Grade 10 to 12. So, I had to recruit two participants teaching Grade 10 from different schools located close to each other to participate in the second phase of the study. The willingness and availability of the two Grade 10 teachers turned out to be beneficial to me, as I realised that these teachers rarely collaborated with their colleagues within or outside the school.

Working together in this study gave participants the opportunity to collaborate as they jointly planned their lessons while focusing on their own learners. I agree with Remillard (2005) who stated that teachers should not teach in isolation but rather be given an opportunity to observe their colleagues when teaching and reflect on their own practices. Unfortunately, participants in this study could not observe each other's classroom teaching due to their different timetable, different teaching periods and workloads. However, they observed the video recorded lessons as they discussed and reflected on their practices. So, if I am to conduct a similar study, I would try to make sure that teachers avail themselves for classroom observation of other teachers and provide room for daily reflection of critical classroom incidents.

Also, the initial plan in my study was for the participants to complete a reflective journal after every classroom teaching and Lesson Study meeting so that I could have a better understanding of how their participation in the Lesson Study process has improved their knowledge and practice over time. However, these participants were reluctant to keep a reflective journal as planned so I requested them to document their reflections on the challenges and benefits of participating in Lesson Study at the end of the study. If I am to conduct this study again, I would conduct tests on participants' content knowledge before and after participating in Lesson Study instead of relying on reflective journals.

6.6 Limitations of the study

As discussed in Chapter 3 Section 3.11, the generalisation of results obtained in this study is impossible due to the nature of the study. However, the aim of this study is not to generalise but to explore physical sciences teachers' views and behaviours towards the teaching of electricity and magnetism within the adapted Lesson Study context. An in-depth analysis of the study was conducted using a qualitative approach. This gave me the opportunity to use different strategies in gaining different insights on how these four participants used the Lesson Study process to enhance the teaching of electricity and magnetism in their respective classrooms.

Teachers' knowledge of learners' difficulties as reported in this study was based on self-reports from participants' interviews. The researcher was unable to assess learners' understanding and difficulties in this topic area. This would have helped me to determine if teachers' response about learners' difficulties in this topic corresponds with the learners' actual difficulties. However, this study was designed to provide an insight into how teachers improve their professional knowledge while participating in Lesson Study and not to focus on the learners.

The constraints imposed by the time factor as a practical situation and the scope of the study also affected this research work. This Lesson Study project was conducted within a short time scale of about eighteen hours of collaborative meeting time on one topic only. Though participants reported positive improvement within this short frame, if participants had taken part in the Lesson Study process over a longer period of time, more substantial evidence could have been gathered through learners' academic outcome and permanent change in teachers' practice.

A study conducted by Grove (2011) on assessing the instructional practice of middle school science teachers shows that a pre-and-post observation could be used to determine whether Lesson Study participants continued with the teaching strategies introduced to them after the intervention was completed. To confirm if participating in this Lesson Study intervention lead to changes in participants' practice as reported, it would have been valuable if I had done a critical assessment of participants' practice before and after participating in this study. Unfortunately, this was not possible because of the scope of the study and teachers' difficulty in finding time to participate in this research. Lesson Study also requires that teachers observe each other's teaching but participants in this study were unable to do so since teachers from the same school had different teaching periods and it is evidently not possible when in different schools. Japanese Lesson Study is focused on the improvement of a specific lesson, this is clearly not possible within this study as staying within the same topic would require more years added. However, the time table and curriculum also exclude the possibility of repeating lessons. Lastly, I was unable to do a follow up on participants' teaching practice after the intervention was completed.

Another limitation considered in this study lies in my interpretation of data obtained during the study as a researcher. It is acknowledged that as a researcher and a facilitator, I may have influenced or misinterpreted participants' views and responses to questions. For instance, during one of the Lesson Study pair meetings and classroom observations for pair A, I was obliged to answer teachers' questions on Faraday's law and electricity, though I ensured that my influence as a researcher and a facilitator on the teachers' content knowledge was minimal. This was however mitigated by using different data collection techniques to enhance the credibility of the study. More so, during the classroom observation, I was able to observe three different lessons per teacher in order to enable me to interpret the data appropriately.

6.7 Contribution of the study

Studies have shown that learners' performance in physical sciences is largely dependent upon teachers' characteristics, subject matter knowledge, behaviour, teaching skills, confidence, and competencies (Ansari & Malik, 2013; Jones & Straker, 2006; Mji & Makgato, 2006; Shulman, 1987). Findings from these studies show that there is a pressing need for professional development programmes that improve physical sciences teachers' behaviours, attitudes, characteristics, and competencies. Existing literature and research have descriptively documented the effect of Lesson Study on teachers' professional knowledge and practice, as noted in Chapter 2 of this study. This research study has critically examined the experiences of four Grade 10-11 physical sciences teachers in selected South African classrooms. All stages of the Lesson Study process, participants' self-report and perception about the outcome of Lesson Study on their professional knowledge and practice, identified benefits and challenges experienced by participants during this research work have been documented. This study therefore contributes towards the body of knowledge on how a change in practice is achieved during participation in the Lesson Study process, by gathering a rich set of data obtained through semi-structured interviews, teachers' reflective writings, the researcher's field notes, observation of group meetings and video recordings of observed classroom teachings. This study was situated within real-life classroom situations and it was conducted during and after school hours. This study is unique in its own context since it examined physical science teachers' use of Lesson Study as a school-based model in teaching electricity and magnetism in South Africa. In addition, this study has provided knowledge through research about contextual factors that affect teachers' participation and continuous practice of Lesson Study. It also clarifies how physical sciences teachers learn together within the context of Lesson Study. It is concluded that this study has contributed theoretically to the body of knowledge on the possibility of promoting Lesson Study as an effective and practical collaborative professional development programme among teachers within and across South African schools.

6.8 Implications and Recommendation

Implications of the study

During this study, I found that physical sciences teachers prefer to teach a particular grade during the academic session rather than teaching different grades. It is possible that teaching a specific subject across the different grade levels could be challenging, however multigrade teaching may improve teachers' knowledge and teaching practices on specific content area. This study suggests the possibility of having more than one teacher per grade teaching different classes as Lesson Study participants.

Interaction with the participants also revealed that none of these physical sciences teachers studied physics or chemistry as a major discipline in their teacher education program. This implies that future content knowledge of teachers might not likely be improved since they sometimes lack understanding of the subject matter knowledge. However, it was observed that these teachers often rely on their subjective experiences and beliefs to guide their classroom teaching. Since electricity and magnetism is a major physics concept that cuts across Grade 10 to 12 physical sciences and grades R to nine natural sciences, there is an urgent need to bridge the gap between teachers' knowledge about effective teaching and their classroom practices.

From my personal reflection into the study, I found that participants' views on contextual factors affecting teachers' participation and possible continued practice of the Lesson Study process were basically pointing to the education policy makers.

Education policy makers and school administrators need to support the practice of Lesson Study as a school-based professional development intervention for physical science teachers and other groups of teachers in the country at large because:

- This will allow teachers teaching the same subject within a school to collaboratively examine and identify issues that arise in their respective classrooms.
- It will also give teachers opportunity to observe each other's lessons rather than working in isolation as indicated by Coe et al., (2010)
- It will improve teachers' awareness of their responsibilities to their learners and allow them to be able to teach them effectively,

- It will help teachers to build a shared vision of how they can collaboratively address significant problems they face in their classrooms and not leave teachers to deal with their classroom problems individually.
- It will help teachers to create a collaborative and shared teaching culture amongst themselves,
- It will create opportunities for teachers to engage in critical and constructive criticism of instructional materials, the teaching process and curriculum matters without fear of being evaluated by school administrators.

Recommendations for future study

During the research study, many issues that need to be further investigated were revealed. For instance, participants' responses to the semi-structured interview provided details about their experiences while participating in Lesson Study which largely supported findings reviewed in the literature. However, participants did not express their views on the long-term effect of Lesson Study on their professional identities and learners' results. Further investigation should be conducted to understand how the pedagogical shift in Lesson Study transforms teachers' professional identities and impact learners' performance. The concern for fear of being criticised was also mentioned as a contextual problem in this study. It is recommended that the need for constructive feedback should be anticipated and discussed with participants in the planning phase and Lesson Study facilitators and other participants should focus on the subject of discussion and be very sensitive to each other's' feelings when giving constructive feedback to observed teachers. Lesson Study facilitators and school leaders need to change their power relation attitude in order to encourage collaboration constructive feedback among teachers.

Results from this research study also points out the shortage of physical sciences teachers, work load, unions, and insufficient instructional resources as practical challenges affecting teachers' participation, and continued practice of the Lesson Study process. Participants in this study found it difficult to find time to observe each other's classroom teaching as practised in Japan. Though Lesson Study is reported in this study to be beneficial to participants, the physical challenges of participating in

Lesson Study are also of great concern. To enhance teachers' participation in Lesson Study, it is suggested that school leaders need to provide a supportive work environment and management structure that supports teachers' participation in school-based professional development programs. It is also recommended that the educational policy makers should develop strategic plans that allow teachers to engage in practical and effective collaborative activities during the school day. Schools should be encouraged to close early once a week, to afford teachers the opportunity to engage in Lesson Study. In cases where lesson observation becomes impossible, it is recommended that participants watch videos of recorded lessons. This would give them the opportunity to critically observe each other's teaching, rationalise each other's choice of pedagogical actions and comment about the learners' learning and teacher's lesson presentation. Considering my personal reflections the factors limiting this study include the small number of physical sciences teachers in a single school, teacher isolation, teachers' job responsibilities and the distance between schools. Further research studies should also be conducted to explore how Lesson Study can be integrated into a district-based professional growth programme for South African teachers. More so, it is recommended that the use of lesson videos and the practice of collaborative teaching should start in teachers training programmes to help reduce professional isolation among teachers.

Lastly, during an informal conversation with Lenox, he mentioned that he used to attend Dinaledi workshops during the Dinaledi period. The Dinaledi school project was established in 2001 with the objective of strengthening teachers' content knowledge, improve the teaching of physical sciences and mathematics, and to increase learners' performance at the matric examinations (Taylor, 2015). However, Lenox believes that the Dinaledi workshops were discontinued because it was not properly sustained and practised in schools. The Department of Basic Education (DBE, 2015) outlined the further education and training (FET) improvement framework for 2016 in its National Senior Certificate examination diagnostic report. This framework indicated that the department may conduct Lesson Study as a remedial measure to improve learners' performance in physical sciences with more emphasis on physics. It is suggested that further investigation needs to be carried out on how South Africa's educational policy and organisational context can effectively adopt, implement and sustain the practice of Lesson Study as a continuous and regular professional growth model for physical sciences teachers (and another group of teachers) across the same school, district, and province. Since this study was conducted on a small scale, it is suggested similar study should be repeated as an intervention approach to a wider population to make a generalisable and substantial conclusion on the outcomes of Lesson Study.

6.9 Conclusions

There is a general concern about learners' low academic achievement in physical sciences, which is linked to teachers' insufficient knowledge about related physics concepts, poor method of teaching the subject, and consistent poor performance of physical sciences learners in South Africa. It is believed that teachers' participation in research-based professional training can help improve their professional knowledge and practice. Research experts in science education have found an international approach that has a great potential of helping physical science teachers overcome the gap between their teaching and learners' learning. This approach involves the adoption of Lesson Study as a research-based instructional strategy to enhance teachers' professional knowledge, skills, and classroom practice and also improve learners' learning. Though such an international approach has been adopted in this study as an in-depth small-scale project, findings from this study have reported positive benefits derived from the approach.

The social constructivist and adult learning theories explain the process of peer learning during interaction facilitated by participants during the Lesson Study intervention. Findings from this study revealed that the collaborative planning session where teachers jointly brainstormed about the research lessons were found beneficial by all four participants. During this Lesson Study intervention, teachers identified learners' challenges in electricity and magnetism. They also discussed strategies that could be used to address identified challenges as well as enhance the teaching of planned research lessons, thus, influencing teachers' knowledge, attitude, self-reflection on classroom practices and confidence while teaching the jointly planned lessons to learners. Prior to Lesson Study, participants reported using direct instruction, explanation, solving several examples, encouraging learners to independently solve problems, simulations, analogies, practical activities and demonstrations as teaching strategies. During Lesson Study, reform based strategies such as whole class discussion, question and answer approach were added to teachers' strategies. This study shows that teachers' content knowledge and pedagogical effectiveness can be improved through structured collaborative learning activities and effective lesson planning. The comparison of the two Lesson Study pairs revealed that Lesson Study pair B was more qualified to teach physical sciences than pair A, pair B also had more instructional and laboratory resources than pair A.

Also, there is a surprising interpretation of 'difficult' concepts in physical sciences as reported in this study. Of particular concern is participants' view that electromagnetism is not difficult because learners are not assessed on the topic at the matric level. This shows that teachers' perception of what difficult means is clearly inadequate and that teachers are more concerned about learners' results than about learners' knowledge and understanding. Though Lesson Study improves teachers' knowledge and classroom practices, findings from this study reveal that Lesson Study seems to be inefficient in cases where there are gaps in teachers' content knowledge. It was also found that the use of Lesson Study as a school-based professional development model contributed to the building of a learning community that encouraged active participation, openness, listening, questioning, and critical reflection among teachers.

However, the four teachers believed that contextual factors such as political issues, school-environmental issues, teacher-related problems, and classroom challenges could hinder their effective and continuous practice of Lesson Study. This conclusion led to suggesting that educational stakeholders should be actively involved and committed in the formation and maintenance of organisational structure that supports teachers' effective participation in continuous professional development programmes like Lesson Study. Policies, reforms and work schedules should be designed to allow teachers to engage in Lesson Study during the school day. Finally, this study contributes to the knowledge base research in understanding how the process of Lesson Study can be used as a form of collaborative action research approach to enhance teachers' knowledge and practice with the aim of achieving quality learners' performance in physical sciences within South Africa.

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APPENDICES

Appendix 1: Letter of permission to Department of Education

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Appendix A

Letter of Permission to North West Department of Education

Ogegbo A.A.
Groenkloof Campus
u15310142@tuks.co.za
Phone: 0743296486
14 March 2016

Dear Sir/ Madam

Request for permission to conduct interviews and do classroom observations
My name is Mrs Ogegbo Ayodele. I am presently enrolled as a doctoral student with student number u15310142 and ID number A03979610 in the Department of Science, Mathematics and Technology Education at the University of Pretoria. The title of my thesis is **Facilitating the effective teaching of electromagnetism through lesson study in selected South African classrooms.**

The significance of this study lies on its unique context of physical sciences teachers' ability to address misconceptions relating to electromagnetism and improving their classroom practice through lesson study. The rationale for this study emerge from the premise that physical science teachers need to find a vehicle for growth and improvement. The collaborative and reflective practice involved in the lesson study model can serve as important method in improving teacher knowledge and seeking new ways of addressing learners' misconceptions in physical sciences.

In order to collect data for this project, I would like to invite willing Physical Sciences teachers from at least five public schools in the Bojanala Platinum district to participate in forming a lesson study group. In lesson study the focus is on the concrete examination of teachers' practice and the testing of new ideas in actual classroom situation. This examination of practice is a collaborative exercise in which the group of selected teachers will plan, design, teach and reflect on Physical Science lessons to enhance learners' achievement.

Teachers will be required to fill a questionnaire on electromagnetism before the commencement of the research. I will interview the teachers individually and observe them in the lesson study group while they are planning the lessons. The teachers will also be observed while teaching the learners and the observations will be video-recorded from the rear of the class. Teachers' and learners' faces will not be publicized. My observations will be discreet. Teachers will be asked to keep a reflective journal of their experience during the lesson study process. The journal will be collected by the researcher at the end of the research. Confidentiality of teachers, learners and the participating schools will be ensured. All data collected with public funding may be made available in an open repository for public and scientific use.

I hereby formally request your permission to conduct my research, observe and interview physical science teachers at selected public schools within the Bojanala Platinum district in the third term of this year. I trust that my request will meet with a favourable response. For any question please contact me on the cell number provided above. You can also reach my supervisor on 012-4205663 or estelle.gaigher@up.ac.za.

Yours faithfully,

.... 07/07/2016..........

Researcher: Mrs. AA Ogegbo Date

.... 2016/07/07..........

Supervisor: Dr Estelle Gaigher Date

Appendix 2: Letter of approval from North West Department of Education

Education and Sport Development
Department of Education and Sport Development
Departement van Onderwys en Sport Ontwikkeling
Lefapha la Thuto le Tlhabololo ya Metshameko
NORTH WEST PROVINCE

cnr Kock and Heystek Street,
Rustenburg 0299
Private Bag X82110
Rustenburg 0300
Tel.: (014) 590-4800
Fax.: (014) 592-3247
e-mail: pmokhutle@nwpg.gov.za

OFFICE OF THE DIRECTOR: BOJANALA DISTRICT

Enq. Dr. ET Matshidiso

To : Mrs. A. A. Agegbo
Ph. D. Student – University of Pretoria

From : Ms. M. P. Mokhutle
District Director – Bojanala District

Date : 12 July 2016

Subject: Request for Permission to conduct research – Bojanala District

Reference is made to your letter dated the 14 March 2016 regarding the above matter. The content is noted and accordingly, approval is granted to good self to conduct research in the 5 sampled secondary schools as requested, subject to the following provisions:-

- That you notify Area and Circuit Managers about your request and this subsequent letter of approval;
- That the onus to notify principals of your target schools about your intended visit and the purpose thereof rests with your good self;
- That as far as possible the general academic programme of the schools should not be interfered with; and
- That upon completion of your research, a report will be send to my Office detailing your major findings and recommendations made and any other relevant information that could be brought to my attention.

Hope you will find the above in order

Thanking in advance

Mokhutle

M. P. Mokhutle – District Director

cc Ms. M. J. Paledi – Area Manager
Dr. Estelle Gaigher – Student Supervisor (UP)

Appendix 3: Letter of approval from Gauteng Department of Education

For administrative use only:
Reference no: D2017 / 338
enquiries: 011 843 6503

GAUTENG PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

GDE RESEARCH APPROVAL LETTER

Date:	**21 October 2016**
Validity of Research Approval:	**6 February 2017 to 29 September 2017**
Name of Researcher:	**Ogegbo A.**
Address of Researcher:	**140 Gerard Moerdky Street; Sunnyside; Pretoria; 0002**
Telephone / Fax Number/s:	**074 329 6486**
Email address:	**u15310142@tuks.co.za**
Research Topic:	**Facilitating effective teaching of electricity and magnetism through lesson study in selected South African classrooms**
Number and type of schools:	**EIGHT Secondary Schools**
District/s/HO	**Tshwane 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.*
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;*

24/10/2016

1

Making education a societal priority

Office of the Director: Education Research and Knowledge Management ER&KM)
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

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 3 and 4 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

....

Mrs F.L. Tshabalala

Acting Director: Education Research and Knowledge Management

DATE: 24/10/2016

2

Making education a societal priority

Office of the Director: Education Research and Knowledge Management ER&KM)
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 4: Letter of consent to School Principals

UNIVERSITEIT VAN PRETORIA
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YUNIBESITHI YA PRETORIA

Appendix C

Letter of Consent to School Principals

Mrs A.A. Ogegbo,
Faculty of Education
Groenkloof Campus, UP.
Leyds Street 0001, Pretoria
u15310142@tuks.co.za
Cell Phone: 0743296486.
14 March, 2016.

Dear Sir / Madam

Consent Letter to the School PrincipalS and HOD Sciences

I am a doctoral student with student number U15310142 and ID number A03979610 in the Department of Science, Mathematics and Technology Education at the University of Pretoria. My research thesis is titled Facilitating Effective Teaching of Electromagnetism through lesson study in selected South African classrooms.

The purpose of this research is to explore how teachers reflect, discuss and teach misconceptions related to electromagnetism within the lesson study context. In order to have better understanding of how the lesson study process influence teachers practice, I will like to involve the physical science teachers in your school. The willing teachers will be required to fill a questionnaire on learners understanding related to electromagnetism. I will also interview these teachers and observe them when planning and teaching the research lesson to learners. This observations will be video recorded from the rear of the classroom.

I would like to conduct this study at your school during the third term. If I am allowed to involve your learners and teachers in my study, permission will be requested from teachers, parents and learners for voluntary participation. Confidentiality of participating schools and participants information will be highly adhered to for the purpose of this study.

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YUNIBESITHI YA PRETORIA

Permission to conduct this research will also be obtained from the North West Education Department. I will also like you to know that all data collected with public funding may be made available in an open repository for public and scientific use. I hereby request your permission to use your school which includes the physical science teachers and learners in this research study.

For any question please contact me on the cell number provided above. You can also reach my supervisor on 012-4205663 or estelle.gaigher@up.ac.za

Yours faithfully,

.... 07/07/2016

Researcher: Mrs AA Ogegbo Date

.... 2016/07/07

Supervisor: Estelle Gaigher Date

I have read this consent form and have agreed / disagreed that the study can be done in this school with the physical science teachers and learners.

Issues regarding participation: ____________________________

Signature ________________________________ Date: _________________

Appendix 5: Letter of Informed Consent to Physical sciences Teachers

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Appendix D

Letter of Informed Consent to Physical Sciences Teachers

Faculty of Education,
Groenkloof Campus, UP.
Leyds Street 0001 Pretoria.
U15310142@tuks.co.za
14 March 2016.

Dear Mr. /Ms................................,

Consent Letter for willing participation

My name is Ogegbo Abosede Ayodele. I am a doctoral candidate in the Department of Science, Mathematics and Technology Education at the University of Pretoria. I am conducting a research study as part of the requirements of my PhD degree in Science education, and I would like to seek your voluntary participation in this research.

The study title is **Facilitating Effective Teaching of Electromagnetism through lesson study in selected South African classrooms.** The purpose of this research is to identify and analyze learners' misconception about electromagnetism, explore how lesson study can be used to improve the teaching of electromagnetism in a Physics classroom and examine the possible factors that might affect the lesson study practice of Physical Sciences teachers. You will be given a questionnaire to fill at the beginning of the study. This questionnaire is not to evaluate you but to help the researcher understand your knowledge about learners misconceptions related to electromagnetism. I will conduct three set of interviews with you before, during and after the research study. These interviews will be conducted at your convenience and audio recorded.

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YUNIBESITHI YA PRETORIA

The purpose of the interviews is to help me understand the teaching strategies employed by Physical Sciences teachers in their Physics classroom, to understand your method of knowledge inquiry on misconceptions relating to electromagnetism, to understand your perceptions, beliefs and experiences on lesson study, collaborative and reflective practice in lesson study.

You will be forming a lesson study team with other Physical Sciences teachers. As a team you will participate in the professional training that will involve: collaborative planning of lessons on electromagnetism, develop learning goals by discussing on what teachers would like students to learn and be able to do at the end of the lesson, design a lesson on how to achieve the stated learning goals, plan on how to observe and collect evidence of students learning. All teachers will teach the planned lesson in their classrooms as the researcher observes you individually and video tape your teaching. The video recorded lessons will be viewed by you teachers as for the purpose of analyzing and reflecting on the your observation by discussing the result and assessing students' progress towards learning goals, document and share lesson study work with colleagues. The generic recommendations from the discussion will be used to plan another topic. All teachers will plan and teach the new topic based on generic recommendations from previous reflection. The classroom observation and lesson study meetings will be video recorded so that I can accurately reflect on what we discussed. The tapes will only be reviewed by me and my supervisor.

All information gathered during this research will be kept in a secure location at the University of Pretoria. Moreover, your identity will not be revealed and pseudonyms will be used in analysis and in the work that will be published as a result of this study. All data collected with public funding may be made available in an open repository for public and scientific use. Your participation in this research study is voluntary. You may choose not to participate and you may withdraw your consent to participate at any time. You will not be penalized in any way should you decide not to participate or to withdraw from this study.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

If you have any question about this study, you may contact me on 0743296486 or ayo3108@yahoo.com. You can also reach my supervisor on 012-4205663 or estelle.gaigher@up.ac.za

Thank you for your consideration.

Yours faithfully,

.... 07/07/2016

Researcher: Mrs AA Ogegbo Date

.... 07-07-2016

Supervisor: Estelle Gaigher Date

Consent

I have read this consent form and have been given the opportunity to ask questions. I give my consent to participate in this study.

Participant's signature______________________________ Date: ________________

Email address______________________________ Contact Number________________

A copy of this consent form will be given to you.

Appendix 6: Letter of Permission to Parent(s) or Guardian(s)

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
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Appendix E

Letter of Permission to Parent(s) or Guardian(s)

Mrs. Ayodele Abosede Ogegbo
Principal Investigator
Groenkloof campus
0734296486
u15310142@tuks.co.za
March 14, 2016.

Dear Parent or Guardian:

I am Ayodele Abosede Ogegbo, a doctoral student from the Science Mathematics and Technology Department at University of Pretoria. I request permission for your child to participate in a research study to be used for my doctoral dissertation. I am conducting a research project on how to facilitate effective teaching and learning of Electromagnetism through lesson study in some South African classrooms. I request for your child to participate. The study consists of the following activities:

- Permission will be obtained from you as a parent or guardian to allow your child take part in 1 to 3 tasks in a physics classroom over a total of about 2 months. Each task will last about 30 minutes to 45 minutes.
- These tasks may include: answering questions about what your child has learned while in physical science classroom and taking short quizzes on topic taught.
- I and other research participants will observe your child while he or she takes part in activities in the classroom while one of the research participants is teaching the class.

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- These activities will be video recorded. The video recorder will be placed in the corner of the classroom and will be operated by the researcher.
- The recorded activities will be transcribed for the purpose of the study only.

At the conclusion of the study, children's responses will be reported as group results. Only I and participants in the research study will have access to information from your child. Information obtained from this study will remain confidential and maintained by means of coding using pseudonyms. Data will be kept in the university of Pretoria data base. The project will be explained in terms that your child can understand, and your child will participate only if he or she is willing to do so. Participation in this study is voluntary.

Your decision whether or not to allow your child to participate will not affect the services normally provided to your child by the school where the research will be conducted. Your child will not lose any benefits entitled to him or her. Your child may choose not to participate even after your permission has been obtained for his or her participation in the study. Your child may choose to end his or her participation in the study at any time if he or she agrees to eventually participate. You and your child are not waiving any legal claims, rights, or remedies because of your child's participation in this research study. All data collected with public funding may be made available in an open repository for public and scientific use. Should you have any questions or desire further information, please feel free to contact the above phone number or email.

Yours faithfully,

.... 07/07/2016

Researcher: Mrs AA Ogegbo Date

.... 2016-07-07

Supervisor: Estelle Gaigher Date

Appendix 7: Letter of Informed Assent to Learners

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Appendix F

Letter of Informed Assent to Learners

Mrs A.A Ogegbo,
Faculty of Education
Groenkloof Campus,
u15310142@tuks.co.za
Cell Phone: 0743296486.
14 March, 2016.

Dear Student

Letter of assent to Grade 11 learners

You are invited to participate in a study aimed at exploring how physical science teachers facilitate the effective teaching of electromagnetism through lesson study. The results of this research will be reported in my PhD dissertation conducted at the University of Pretoria and also published in educational literature or presented at educational meetings.

I would like to observe your physical science teacher during third term of this year while teaching physics concept of electromagnetism lesson to your class. The observation will be done once in a week for a period of five weeks and it will not interrupt your school activities. The lessons will be video recorded and confidentiality of learners will be highly maintained. Information and data obtained during lesson observations will not be linked to names of learners.

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Your participation in this study is highly confidential and voluntary. If you declare yourself willingly to participate in this study, your parents will be asked to grant consent for your voluntary participation. You may choose not to participate and you may decide to withdraw your consent to participate at any time. Your decision to continue or withdraw will not affect your grades or experience in class. Please sign this letter as a declaration of your assent, if you are willing to participate in this research study and understand that you can withdraw from the study at any time. All data collected with public funding may be made available in an open repository for public and scientific use. For any question please contact me on the cell number provided above. You can also reach my supervisor on 012-4205663 or estelle.gaigher@up.ac.za

Yours sincerely

Researcher: Mrs. A.A Ogegbo — Date: 07/07/2016.

.... — 2016-07-07

Supervisor: Dr Estelle Gaigher — Date

Please sign the form

I understand the project and hereby grant assent to Mrs. Ogegbo to conduct her research as I voluntarily participate in this study.

Participant's signature .... Date ....

Appendix 8: Lesson Study Lesson plan template

Teacher's Pseudonym: …………………… Lesson duration: ……………

Date: …………………………………. Grade: ……………………………......

Subject: ……………………………. Topic: ………………………………

Sub topic: ……………………………………………………………………………...

What is the importance of this topic to the learners?	
Resources: Material and Apparatus: What is the teaching model/ approach you will use for this lesson?	
What are your Goal(s) / Objective(s) for this lesson?	
What should learners already know (previous knowledge)?	
What should learners know after this lesson?	
What are the vocabulary terms associated with this topic:	
Lesson Introduction:	
Learners' class activity	Teachers 'expectation of learners' response
Closing (How do you wrap up /conclude the lesson):	
Teacher's Feedback to learners about the class activity (in terms of correction):	
Home work:	
Teachers reflection on the lesson taught:	

Appendix 9: Interview Protocol

Teacher's Pseudonym: ……………………………………………………………

Date: ………………………………………………………………………………

Highest Qualification: ……………………………………………………………

Years of teaching Physical sciences: ……………………………………………

School: ………………………………………………………………………………

Gender: ………………………………………………………………………………

Appendix 9A: Initial interview

Teachers' ideas about learners' difficulties in Electricity and magnetism

- In your experience as a Physical Science teacher, what can you say about learners' difficulties and misconceptions related to electricity and magnetism?
- How common are these difficulties and misconceptions among learners?
- How does learners' difficulties and misconceptions in this topic affect your classroom practice?
- How do you address the difficulties and misconceptions that learners have in electricity and magnetism?
- How do you know that a learner has successfully overcome the difficult concept and misconceptions in this topic?
- As a teacher, is there any concept under electricity and magnetism that appears confusing or difficult to you?
- Do you discuss these difficult concepts related to electricity and magnetism with your colleagues outside lesson? If yes, How? If no, why?
- When you are teaching, what do you look for as evidence of student learning?
- How much do you reflect about your learners' difficulties and misconceptions in relation to topics under electricity and magnetism? When do you reflect on these difficulties?
- What do you reflect on after teaching concept related to electricity and magnetism?

Appendix 9B: Final interview
Questions on Lesson Study

- How will you describe Lesson Study?
- What did you learn while participating in Lesson Study?
- What has been the most interesting aspect of your Lesson Study experience? Why?
- What has been the most challenging aspect of your Lesson Study experience? Why?
- Which of the Lesson Study processes do you think is more valuable to you? Why?
- How can you explain the role of collaborating with other colleagues in Lesson Study?
- What is your perception about the impact of Lesson Study on your professional knowledge and classroom practice?
- What are those factors that might possibly affect Physical sciences teachers' practice of Lesson Study?

Appendix 10: Lesson Study pair observation protocol

Group Observed	
Observer	
Topic	
Date	

Checklist for group observation

	Criteria	**Researcher's comments**
1.	Teachers value the contribution of one another and opened to different points of views	
2.	Teachers demonstrate content and pedagogical knowledge as a group while preparing for the lesson	
3.	Criticism is constructive and there is collegial challenging of diverse ideas	
4.	Teachers share responsibilities among each other	
5.	Teachers identify learners difficulties in the topic and demonstrate knowledge of learners interest	
6.	Teachers manage time	
7.	Teachers monitor how they understand information and plan activities	
8.	Teachers monitors their progress and adjust their processes to become more effective when appropriate	
9.	The teachers set out instructional outcomes and determine learning goals	
10.	Teachers consider several ways of solving learners perceived difficulties before deciding what method works best	
11.	Teachers design relevant instruction and learners assessment	
12.	Connections are made between past learning, current goals and intended applications	

Appendix 11: Classroom lesson observation protocol

School	
Date of lesson observation	
Subject	
Grade	
Number of learners	
Topic Observed	
Lesson time	

Checklist for teacher's classroom lesson observation

Observed Element	**Criteria**	**Evidence**
Assessing learners learning	Did the teacher assess learners' previous knowledge?	
	Did the teacher check for learners understanding of the lesson taught?	
	Did teacher ask learners to solve problems based on lesson taught.	
Instructional delivery	Did the teacher present an overview of the lesson?	
	Did the teacher engage the learners in a whole class activity?	
	Did the teacher manage the disruptive behaviours of learners?	
	Did the teacher present the lesson to meet the planned objectives?	
	Did the teacher clarify learners' misconceptions during the teaching?	
	Did the teacher demonstrate knowledge of various teaching practices?	
	Did the teacher integrate examples from real world into the teaching?	
	Did the teacher emphasize important points while teaching?	
	Teacher use relevant activities to clarify key concepts?	
Classroom interaction	Did the teacher encourage small group/ paired activities among learners?	
	Did the teacher encourage individual /independent work among learners	

	Did the teacher write key terms on the board?	
	What lecturing activities did the teacher use in disseminating knowledge?	
	Teacher create a good classroom environment for teaching learners?	
	Did the teacher relate well with the learners?	
	Did the teacher support learners learning?	
	Did the teacher encourage learners to participate in the teaching and learning process?	
	Teacher effectively manage the classroom?	
	Teacher create an environment of interest for learners while teaching this lesson?	
Teacher's knowledge	Did the teacher demonstrate knowledge of required concepts in the subject matter?	
	Did the teacher conduct practical activities?	
	Was the content of the lesson presented to meet learners need?	
	Is the teacher committed and enthusiastic about the lesson and learners learning	
	Did the teacher show empathy towards learners' inability to understand the lesson?	
	Did the teacher provide learners with accurate feedback?	

Appendix 12: Document analysis guide

Teacher's Pseudonym: ………………………………………………

School (Pseudonym): ……………………………………………..

Date collected: ……………………………………………………….

Document analysis Guide: Teachers document (lesson plan)

Significance of this document: To know how teachers originally plan and prepare for their lessons.

Criteria	**Comments**
Teacher's description of how the lesson fits into a larger curricular unit	
Activities in teacher planning that assessed or stated learners' prior knowledge	
Outline of inquiry methods to be used while teaching the lesson	
Outline of teacher's expectation of what learners should know and be able to do at the end of lesson	
Instructional materials teacher's used in the class while teaching the lesson	
Content/procedure standard	
Teacher's feedback to learners	
Teacher's wrap up/ conclusion	
Planned learners' assessment	
Notes for teachers to reflect on the lesson taught.	

Appendix 13: Interview transcript from Lesson Study pair A

Appendix 13A: Lenox' interview transcript

Lenox pre Interview transcript collected 2/9/2016

Researcher's note	Interview questions	Codes	Sub themes	Themes
Lenox did not clarify if he has any other qualification before obtaining his ACE.	**Researcher:** What is your highest qualification as an educator? **Interviewee:** The only qualification I have is my ACE (Advanced Certificate in Education) with specialization.	Teacher's qualification	Subject knowledge	Teacher's professional competence
His qualification indicates that he has a general scientific knowledge required to teach the subject	**Researcher:** So what is your specialization? **Interviewee:** Mathematics and Science Education. But you know …hmmmm... Science is wide so as a teacher I think one has to have a discipline or specialty like being a Physics or a Chemistry major. It will make you more professional. You know what am saying.	Teacher's subject specialization Teacher's own knowledge	Subject knowledge	Teacher's professional competence
Teacher indicated that he does not like teaching Physical Science because it is difficult but his action showed that he is gradually growing his confidence teaching the subject. His response also showed that he is not interested in further studies except for leadership roles.	**Researcher:** You said your highest qualification is ACE, as a teacher why dint you further your studies. **Interviewee:** I never intended to be a teacher. I became a teacher by default. My parents passed away and the person taking care of me said its better I become a street boy or a teacher since ACE was free as at that time. My desire is to be an engineer but I opted to do ACE because it was free. So it is not as I love teaching but now I am falling in love with the profession. However, even if you have ACE or diploma or degree, I came to realize that we all	Love for profession; Teacher's attitude towards further studies; Teacher's perception that math and science is difficult; Teacher's financial expectation as a science instructor;	Teacher's character	Teacher's professional competence

	receive the same salary so what is the benefit of wasting my money and time for. But don't get me wrong, I am still going to do a degree but that is when I am about to get one of this leadership role either as H.O.D or something. If I am doing a degree it will be in another course and not in math or science because math and science is difficult I tell you. As math and science teachers, the government should be paying us science fees or incentives because we sacrifice a lot for these field.	Teacher's perception; Teacher's belief		
It seemed Lenox believes that learners don't have problem in specific topics since they are not assessed at the matric level, electromagnetism is not considered difficult.	**Researcher:** In your experience as a Physical sciences teacher, what can you say about learners' difficulties and misconceptions in electricity and magnetism? **Interviewee:** To those of us marking, we believe that learners have problem with Energy theorem and electricity. Although electricity or electric circuits as they call it is very simple but learners still find the topic difficult. Now pertaining to electromagnetism. When we moderate for marking, we hardly consider electromagnetism as a difficult topic because learners are not assessed on that topic at the matric level.	Teacher's belief on learners learning difficulties; Teacher's perception on the simplicity of electricity Teacher's attitude towards electromagnetism;	Teacher's character	Teacher's professional competence
		No learners' assessment at matric level. Subject knowledge	Knowledge of learners	
His response indicates that Lenox has an attitude towards teaching electromagnetism as a	**Researcher:** Why don't you consider electromagnetism as a difficult topic? **Interviewee:** Well, I think the reason is not farfetched. Learners are not assessed in that	Learners assessment; Learners understanding of topic;	Learners knowledge	

concept under electricity and magnetism.	field probably because the topic is newly introduced or........... But seriously, if I am to look at it from my own view, learners and some of us educators still don't understand the concept of electromagnetism very well. Since we don't do much about that topic in grade 12, we don't put much importance to the topic as compared to other topics and I am certain that it is wrong.	Teachers understanding of content;	Subject knowledge	Teacher's professional competence
		Teacher's own content knowledge		
		Teachers attitude when teaching Electromagnetism.	Teacher's character	
He mentioned that some concepts related to electricity and magnetism are abstract in nature which allows learners to place an immediate barrier and fear understanding the topic.	**Researcher:** Okay, so from your own classroom experience, what are the difficulties or misconceptions you think learners face in electromagnetism? **Interviewee:** See Ga ke tlhaloganye ....I really don't understand these learners but I think this problem starts with the introduction to electricity and magnetism as at grade 10. In electromagnetism learners find it difficult to identify the direction of magnets in a solenoid. Also this in-page and out of page description in the curriculum or the text books are not explanatory enough to some of them. Another thing I may say is that these learners don't really understand the meaning of change of magnetic flux and because of this when they are asked some questions they don't know that changing the area of a coil will automatically change the flux. In electrical circuits, these learners have the same fear for electric circuit as they have for	Teachers perception on learners problem	Teachers' own knowledge	Teacher's professional competence
		Teacher's own content knowledge ;	Knowledge of learners	
		Teacher's understanding of learners difficulties;		
		Learners previous knowledge background		
		Learners understanding; Fear for Mathematics;		
		Learners belief;		
		Learners' inability to visualize the topic.		
		Teacher's reaction to common learners difficulties;		

	Mathematics. So they put this immediate barrier that they cannot do it once they hear electricity. So I will say the general fear is that electricity is difficult to comprehend. Also they cannot differentiate between parallel and series arrangement and the situation becomes worst when you combine parallel and series arrangement in a circuit diagram. They don't understand the difference between electromotive force and potential difference, so calculating it becomes a night mare to them**.** Eeeem...my sister, so you see that if they cannot visualize the topic or maybe I call it the concept, then they see it as abstract and all they do is just memorize for the sake of passing the exam.	Learners negative reaction to Physical sciences.		
		Teacher's confidence;	Teacher's attitude	
		Teacher's interest;		
		Teacher's enthusiasm		
He believed that learners' level of comprehension on concepts related to electricity and magnetism is the same in all schools and cuts across all grade level.	**Researcher:** How common are these difficulties and misconceptions among learners? **Interviewee:** hmmmm….some learners are outstanding and some are just …….you know so the commonality of these difficulties depends on the group of learners an educator is teaching but you know that we will always have the underperforming and the outstanding learners in every set. More so these problems are common in all schools and across all grades because they do not practice and the do not do homework. Physical sciences is all about practice, practice, practice.	Teacher's perception about set of learners a teacher is teaching	Teacher's belief	Teacher's professional competence
		Learners attitude		
		Learners performance	Knowledge of learners	

Teacher reflected that he is not too enthusiastic about electromagnetism as a concept	**Researcher:** You have just mentioned the difficulties learners' face, so how confident are you when teaching this topic electromagnetism knowing learners don't understand the topic? **Interviewee:** Smiling.....seriously I am not too confident teaching a topic like electromagnetism because even as a teacher I don't like the topic too. The topic is just too......... I don't know how to explain.	Teacher's confidence Teacher's interest	Teachers' attitude	Teacher's professional competence
He mentioned that learners develop misconceptions and difficulties from grade 8.	**Researcher:** How does learners' difficulties and misconceptions in this topic affect your classroom practice? **Interviewee:** You know these difficulties and misconceptions as you put it were from their grade 8/9 probably because the teachers who taught them did not do their job well. But for me I have learnt to always try introducing the basic to them again before moving on with what they expected to know at grade 10 to 12. Although this step takes me back a lot and consumes most of time. And to be sincere with you, sometimes I just carry on with my (thuto) teaching if I see that I don't know how best to explain to them again.	Teacher's pedagogical practice Learners previous knowledge background Time consumption Teacher continues teaching without clarifying difficulties.	Pedagogical practice Teachers' belief Teachers attitude	Impact on practice
Lenox's response indicates that he uses more of direct instruction and solved examples in addressing his learners' difficulties since they lack	**Researcher:** How do you address the difficulties and misconceptions that learners have in electricity and magnetism? **Interviewee:** In electrical circuit, I do tell them to first take up the parallel arrangement, solve it the put it back in the circuit diagram to calculate	knowledge of teaching strategies; giving specific instruction	Pedagogical skills and practice	Teachers professional competence Impact on practice

resources for practical activities.	the series circuit. For electromagnetism I try as much as possible to do practical activities whenever apparatus are available and I encourage them to carry it out individually. Above all I will say I use quite a numerous examples to address their difficulties.	Expectation from learners; Practical activities use of several worked examples		
He was certain that his method work for some of learners even though his reaction showed otherwise.	**Researcher:** Has your method or approach in addressing these learners' difficulties been effective? **Interviewee:** I won't say it works all the time but I will say at least it works for 60% of the learners and the remaining 40% sort it out with their colleagues. These 40% are learners who should not take the subject but they are been mandated to do so by their parents and the government has asked us not to discourage any learner who has shown interest in taking the subject.	Teacher's confidence; Learners interest Parental influence Government influence	Teachers' character Teachers' belief	Teachers professional competence Impact on practice
He expected the learners to ask questions whenever they don't understand; since that will make him know if the learners' difficulty had been addressed or not.	**Researcher:** How do you know that a learner has successfully overcome the difficult concept in this topics? **Interviewee:** Smiling.......by assessing them. I sometimes give them on the spot test which does not last more than 5 minutes. Though the assessment is just a formality. I expect the learners to ask questions when they don't understand or come to me when they have difficulties understanding a concept. So I believe if they ask questions then they don't understand and if they don't ask questions simply implies	Learners assessment On the spot test Teacher's expectation from learners;	Pedagogical skills and practice Teachers' attitude	Teachers professional competence

	that they understand whatever it is they were taught.			
He was confident about teaching grade 10 and 11 topics but not too confident about teaching topics in grade 12.	**Researcher:** As a teacher is there any concept in electricity and magnetism that appears confusing or difficult to you? **Interviewee:** Hmm……not really in grade 11 but for grade 12 am still not confident with teaching the concept of generators and motors. I just have to read, read and read to understand some things at the grade 12 level. This will be my second year of teaching grade 12.	Teacher's confident Teacher's preparation Teacher's difficulty	Teachers' attitude	Teachers professional competence
His response indicated that he does not really participate in collaborative sessions with colleagues when planning lesson	**Researcher:** Do you discuss this difficult concepts with your colleagues in/outside the school? **Interviewee:** yes, I am very open to my HOD because she also teaches Physical sciences and I also have colleagues in other schools who I call on phone to ask them questions on whatever challenges or difficulties I am having in my class or with a particular lesson. But we don't have enough time to sit down together and discuss due to extra activities in the school which requires our attention.	Exchange of ideas through phones; Teacher rarely involves in practical group discussion with colleagues Availability of time Teachers job responsibilities	Teachers' attitude Teachers' work challenges	Teachers' collaboration Contextual conditions
He had a perception that the only way to know if students are learning is when they ask question.	**Researcher:** When you are teaching, what do you look for as evidence of student learning? **Interviewee:** Whenever I give them exercises**,** I expect that the learners will come to me and ask	Teachers expectation from learners	Teachers' attitude	Teachers professional competence

	questions so their ability to do this indicates to me that they are learning because I tend to engage them in a kind of discussion process when trying to answer their question.	Learners' engagement in class discussions.	Pedagogical practice	
His response showed that he only reflects based on his classroom situation (action) and his reflection is always done at the end of the week.	**Researcher:** How and when do you reflect about your learners difficulties in this topics? **Interviewee:** I do my reflection after teaching and I will say it is weekly. I do these in several ways depending on the classroom situation. For instance, in today's class I gave the learners individual class activity and I was able to mark few of them. I found out that 20% of the learners answered the question correctly and the other 80% some did not even attempt question while some got it all wrong. Now this made me realize that I still need to explain the particular concept again because it's an indication that the learners don't understand the topic as I have expected them to. I think that is one of my own ways of reflecting right there.	Teachers' reflection Time of reflection Teacher reflects on action: to solve immediate problem at hand.	Teachers' pedagogical practice	Teachers professional competence
He mentioned that he has not attended any form of PDT in five years.	**Researcher:** How often do you attend practical professional development trainings/workshops? **Interviewee**: At the moment we are not really into professional development…..In five years now I have not attended any? But previously I	Teachers need for practical professional development	Professional development need of teachers	Impact on practice

	do attend dineledi workshops and I involve myself in marking the matric examination because it exposes more on what the department is expecting from the learners and how they should answer some questions**.**	Teacher's participation in other forms of personal development		
He believes that Physical Science teachers need professional expert (subject adviser) to help them with some challenges they are facing.	**Researcher:** In five years………but why? **Interviewee:** Laughing......you see my sister, the problem is from the district. We don't have a subject adviser and that has been affecting us Physical sciences teachers?	Need of a professional expert (subject adviser)	Professional development need of teachers	Impact on practice
He is of the opinion that having a subject adviser will give them more opportunity to collaborate and share their problems with an expert or other colleagues since they have no one to turn to for help.	**Researcher:** How has it been affecting you? **Interviewee:** haaaaaaa... seriously speaking, for many educators especially the new ones, it is going to be a very big problem because i know they are definitely facing problems in their classrooms and they don't know how to resolve those problems. So I will say they are left to handle the challenges on their own. For people like me who have been teaching the subject for quite some time now, I will not say I am not affected but I know how to solve my problems and I have colleagues in other schools which I can easily call. Above all remember I also mark, so sometimes during moderation we discuss some of our classroom challenges but having a subject adviser would have been the best.	Teachers perception about newly recruited teachers New teachers are left alone in the class	Teachers' belief	Impact on practice

Lenox Post Interview transcript collected 22/9/2016

Researcher's notes	Interview Questions	Codes	Sub Themes	Themes
He seemed to have an understanding of how Lesson Study can be used as a good form of professional training but he believes that Lesson Study is contextual.	**Researcher:** How would you describe Lesson Study? **Interviewee:** Lesson Study.................... what can I say? Hmmmmm ...it is a good training actually I think it helped me in managing my learners and also improved discipline in the areas where I tends to involve my learners in more activities but I think that also depends on the nature of the topic one is teaching. What more? It helped me in assessing how my learners think. And it's a good way of allowing other teachers to see what goes on in my class.	Focus on learners' activities; Assessing learners thinking; Develop classroom management skills; Build class discipline Opportunity for colleagues to see what happens in your class;	Description of Lesson Study Benefits of Lesson Study	Lesson Study experience
He mentioned his ability to observe and understand how individual learners think as a positive experience he gained while participating in Lesson Study	**Researcher:** What has been your experience while participating in Lesson Study? **Interviewee:** My experience….. You know, I thought at first when you explained this whole process, I saw it as something that cannot work and impossible to actually achieve but later on I realized it is possible and might be effective but unfortunately time will not permit and it cannot be done in schools where we have just one Physical Science teacher teaching grade 10 to	Teacher's perception Time management Teacher's Work load Lots of commitment Focus on learners' observation	Benefits of Lesson Study (change in teachers' belief) Challenges of Lesson Study Benefits of Lesson Study	Lesson Study experience

	12 and also teaching natural sciences. But for me I am too busy with a lot of things so I don't really have the time collaborating with other colleagues. I have too much on my table. But one thing I will say is that I may try this with my learners for grade 11 next year. Before I forget my experience participating in this study is something I will say it's a bit difference from other programs I have attended because I was able to observe a particular learner over the entire lesson and I tried understanding how this learner thinks whenever I ask him to answer a question in the class. This is something I have never done with any of the learners before and I think this is a good method but for small classes and not a big class like this.	Understanding learners thinking	(Teacher learning)	
In his response he mentioned that thinking about how the learners will respond to question was an interesting section.	**Researcher:** What aspect of these Lesson Study process is more interesting to you? **Interviewee:** Smiling.....what I think is interesting about this process is the aspect of giving me the opportunity to anticipate about my learners' response and what they think. I really love the opportunity given to me to make quick judgement on what I think works best for my learners.	Focus on learners learning; Judgement of learners' assessment method Anticipating learners response	Benefits of Lesson Study (teachers' learning)	Lesson Study experience
He stated that Lesson Study is time consuming	**Researcher:** What aspect of these Lesson Study process is more challenging to you?	Collaborating together		

and requires a lot of commitment.	**Interviewee:** Challenging…….. sitting together. Personally, I am a person that don't like .... because I am just too busy to sit down and waste my time. This school does not do things accordingly. Since I am of the union representative here, so have got much on me plus the school give you tasks at any time and they expect you to be up and doing in everything. Another challenging aspect is this goal setting, it's not difficult but requires a lot of thinking in order to align it with the curriculum.	Job responsibility Planning lesson goals Time required	Challenges of Lesson Study	Lesson Study experience Teachers' collaboration Contextual conditions
In his response, he believed that the presence of another teacher in class had a positive impact on how learners respond to questions.	**Researcher:** Alright.... so what do you think is the most important aspect of this whole process for you? **Interviewee:** The most important aspect was the ability to focus on two of my learners who I actually taught are unserious because they are too playful and don't look serious but calling them out to answer questions and the manner they responded particularly in the last two lessons you observed was something significant to me. They responded well and answered the questions asked logically. Probably may be because you were in the class. So it made me happy and I felt the lesson was worth it after all.	Learners focused observation Teacher's perception about case learners Learners observed class performance Effect of another teacher in the class	Benefits of Lesson Study Teachers' learning	Lesson Study experience
He believes that collaboration helps to reduce isolation and	**Researcher:** Considering the collaboration aspect of this Lesson Study, how has it affected your professional practice?	Increase teacher's confidence	Benefits of Lesson Study	Lesson Study experience

build individual's confidence.	**Interviewee:** you see... I think it is all the same thing. This opportunity has helped me to use my classroom experience to increase my colleagues' confidence. It has also improved my teaching skills now that I have learnt new approach to teaching some concepts. And eeem… you know collaborating together as teachers in the same school gave me the opportunity as well to manage instructions together.	New approach to teaching Increase teacher's competency Instruction management	(change in teachers' attitude and Pedagogical skills	Teachers' collaboration
He was confident that participating in Lesson Study has really helped him with his content knowledge, pedagogical knowledge and use of various texts in solving problems.	**Researcher:** In what way has your participation in this study enhanced your classroom teaching? **Interviewee:** You see.....smiling......not that I don't have the basic knowledge required in teaching this topic but I believe that my participation in this practical training has also to some extent increased my knowledge of Physics and I feel if I continue this practice with learned colleagues my understanding of some Physics concept will change for the good. So in a simple sentence, I will say my knowledge of electromagnetism is improving and my Mathematics knowledge with respect to the required concept needed in Physics is also	Teacher learning Increased subject knowledge Improved specific content knowledge Improved knowledge of required Mathematical concepts	Subject knowledge Benefits of Lesson Study	Impact on practice

	gradually improving. Then ....sesi...frankly speaking, you know one can be teaching for many years and still don't have confident teaching some topics probably because you don't have interest in those topics but now think I have a feeling that I am beginning to build my own self confidence in some aspects of this Physics concept you are trying to research on and I will say that this Lesson Study training has positively affected my method to learning some Physics concept by allowing me to visualize Physical sciences in a more practical way than I use to. One thing that I have also realized is that there are different ways of thinking about a solution. So how I think about a solution is not necessarily how my learners will look at it. So now I try using more than one method of coming up with the correct answer which has given me more confident to not always rely on the curriculum alone but use varieties of text to widen my knowledge of the best possible approach to use. This aspect of planning where you anticipate learners' responses to questions asked in the class has actually helped me to be in tune with what the learners are likely to respond to and not respond to. And you know ....eeeem this provides more information to the teacher when planning and teaching a lesson.	teacher's confidence Ability to use several teaching methods Anticipating learners' response during planning Teacher's analytical thinking Knowledge of using more texts.	Teachers' belief Pedagogical skills and practice	Lesson Study experience
Teacher believed that Lesson Study cannot		Time factor	Resources	

work except the required resources (time, materials, and experts) are put in place and approved by the education policy makers.	**Researcher:** Are there any factors that might possibly affect your continuous use or practice of Lesson Study as a teacher? **Interviewee:** Obviously.... time factor because the curriculum is loaded and we have few Physical sciences teachers in school so it's difficult telling me to sit and plan a lesson with other teachers. Besides lesson planning is quite impossible and can never work because we have different school or classroom situations and different learners. Remember these association people did not evenencourage us as teachers to use the lesson plan. Another reason why it will not work is because the school manager always wants you in class and the moment they see teachers gathering together they believe you are not doing your job. So, if you try explaining to them that you are doing things like this, they see you as a threat trying to dictate or take over their position from them and suggesting programs like this to the area office without the manager's awareness is like looking for more trouble where there is none. You know what I mean so don't let me go into details. Then I feel this thing of not having specialized teachers might be a problem	Need for specialized teachers Low number of Physical Science teachers Curriculum overload Power relationship Writing lesson plan Joint lesson preparation Differentiated classroom situation	 Work load Leadership Methods involved Classroom environment	Contextual conditions
He was of the opinion that Physical sciences	**Researcher:** What do you mean by specialized teachers?	Subject specialization		

need to be offered as separate subject of Physics and Chemistry	**Interviewee:** You see, in my understanding Physical sciences in other countries is offered as Physics and Chemistry separately but here it is not. So, when you are not specialized in a particular field you cannot know every detail of that subject. If I can put it that way.	Belief about teachers' education	Teachers' perception	Contextual conditions Teachers' professional knowledge
He mentioned that the work load and job responsibility as a teacher does not create time to involve in extensive collaboration with colleagues outside the school.	**Researcher:** Okay.... You also mentioned that collaborating with other colleagues is a waste of time.... why? **Interviewee:** I will be serious with you. The system in place at the department and even in this school is a bureaucracy because learners are just admitted into the system for the sake of increasing the incentives and salary given to the school Manager. The promotion criteria is not.......... So, the manager is not interested in your wellbeing all she wants is result. They don't care about your challenges or what you face in the class and the learners are just too much. Imagine I have 245 learners in grade 12 and 340 learners in grade 11. How do you expect me to be productive, marking all their homework and class activity? So you that time is not visible in this unless the department or principal gives time and employs more teacher to help.	Learners promotion criteria Teacher's welfare Leadership power Teacher's workload Time Class size	Teachers' work challenges	Teachers' collaboration Contextual conditions
He reflected on why he does not write lesson	**Interviewee:** now I don't know what you mean by lesson plan because the association is not in			

plan and his attitude indicated that he will feel humiliated if someone comes and question how he plans his lesson.	agreement with it. I will say lesson plan is for the department and not for me. Seriously I don't write lesson plan. My plan is on my xixingiwa…..laughing…..i mean lap top, as you can see for yourself. All I do is teach according to the curriculum and ensure that these learners are exposed to the necessary practical outlined in the curriculum.	Attitude towards writing a detailed lesson plan	Teachers' belief Teachers' attitude	Teachers' professional competence

Appendix 13B: Mbali's Interview transcript

Mbali pre Interview transcript collected 5/9/2016

Researcher's note	Interview questions	Codes	Sub themes	Themes
Teacher has a formal credential which in her reaction gave her the confident as to being a Physical Science teacher.	**Researcher:** You said your highest qualification is diploma and ACE, can you please explain it to me clearly. **Interviewee:** I did my diploma in math literacy which is 3 years and ACE in science for 2 years.	Teacher's qualification	Subject knowledge	Teachers' professional competence
In her response, she started teaching Physical sciences because the country does not have	**Researcher:** Alright, now you said you have been teaching for 9 years? **Interviewee:** Let me clarify what I meant by that statement. I taught math literacy for 7 years and have been teaching Physical sciences for 3 years now.	Teacher's years of teaching experience	Subject knowledge	Teachers' professional competence
She opted to teach Physical sciences because of the country's challenging needs of Physical Science teachers.	**Researcher:** being a math teacher why did you decide to start teaching Physical sciences. **Interviewee:** 'iyooooo'…. smiling, you know we don't have enough Physical Science teachers in South Africa and I think my ACE gave me an opportunity to be one.	Reason for being a Physical Science teacher Low number of Physical sciences teachers teacher's preparation degrees	Teacher's attitude	Teachers' professional competence

Teacher believes that learners' difficulties and misconceptions in electricity and magnetism was developed as a result of their negative perception and attitude towards Physical sciences in general.	**Researcher:** Okay, In your experience as a Physical sciences teacher, what can you say about learners' difficulties and misconceptions in electricity and magnetism? **Interviewee:** Oh, learners' difficulties and misconceptions in Physical sciences is prevalent because learners believe that the subject is difficult and I will assume that this is due to their un-seriousness. In my years of teaching I can say that learners don't and are not ready to understand this particular topic (electromagnetism) because they can't seem to visualize the concept in their environment. So they see the topic electromagnetism as an abstract and difficult concept to comprehend.	Teachers perception about common learners' difficulties Learners belief Learners attitude;	Knowledge of learners	Teachers' professional competence
She was confident of the learners' difficulties in the topic of interest and was able to demonstrate her content knowledge of the particular concepts related to electricity and magnetism.	**Researcher:** What are these difficulties and misconceptions? **Interviewee:** They struggle with Faraday's laws of induction, direction of induced current, magnetic field, solenoid and how to determine the direction of field at particular angles. Something I think........ I noticed as well is that some learners take direction of field as flow of	Teacher's understanding of learners' difficulties; Teacher's own content knowledge; Learners understanding	Subject knowledge Knowledge of learners	Teachers' professional competence

	current. Then you see this concept of magnetic field associated current carrying wires....yooooooo it is confusing to learners and even to some educators. In electricity, learners don't know how to correctly substitute equations when solving problems and funny enough am still shocked that these learners can neither state nor apply Ohms' law correctly.	Learners Mathematical problem		
Mbali considers learners' difficulties to be the same in all schools and across all FET grade level because of the promotion standard.	**Researcher:** How common are these difficulties and misconceptions among learners? **Interviewee:** hmmmm…..these difficulties are very common and it cuts across grade 10 and 11, 12 because when learners don't pass Mathematics and physical sciences in one grade they will still be promoted to the next grade once they are able to pass 6 or 8 subjects. So whatever problem they are struggling with for instance in grade 10, they move with it to grade 11 and 12. So you find out that these learners don't have the basic understanding of Physical sciences topics at grade 10 then how do you expect them to build on it at grade 11 and 12. It becomes a big problem for educators teaching grade 11 and 12 learners. We cannot teach them the basics at this grade so we just try our best to explain in our own little way but remember the foundation is weak.	Teachers belief Promotion criteria; Lack basic understanding of Physical sciences concepts; Teaching methods and approach.	Knowledge of learners	Teachers' professional competence

The teacher affirmed that learners' difficulties in Physical sciences is common due to the external factor impacting on learners' individual choice of choosing the subject they want.	**Researcher:** Why do you think these difficulties are common? **Interviewee:** Presently I teach grade 11 commercial and science learners with grade 12 technical learners. So I will say that the problem is common because they are not really interested in the subject. They only offer the subject because their parents mandate them to do Physical sciences, more so the government promotes the subject as very important. However, these learners don't read on their own, if you give them home work they come back the next day to copy their colleagues. One thing I also think it's responsible for this common difficulties is that most of the learners don't have text book and work book. They rely on the government for everything and the government is not supplying enough. So learners don't have text books and work books to use and they don't wait for extra lessons. For instance, I have about 250 learners and government only supplied about 100 text books.	Learners interest; Parental factor; Government policy; Learners don't practice; Unavailability of learners' resource materials (textbook, workbook); Learners attitude;	Knowledge of learners	Teachers' professional competence
Her response indicated that the class size has a significant effect on her teaching work load and teaching time.	**Researcher:** You said you teach grade 11 science and commercial then grade 12 technical. So how many learners are you teaching in all.	Learners' population (class size);	Work load	Contextual conditions

	Interviewee: For grade eleven I have about 250 learners and grade 12 I have 170 learners. So you can imagine the total number of learners I am handling. Moreover, we are also preparing the grade 12 learners for their exam so the pressure is more on us.	Teacher's workload		
Teacher's ability to improvise textbooks for learners indicates that she has the interest of the learners at heart. Teacher's practical demonstration skills on electromagnetism is based on traditional teaching method.	**Researcher:** So how are you managing this situation? **Interviewee:** Basically I pair the learners when we need to use the text book and when the text book is not sufficient, I make few photocopies of the page needed. For the class activity, I make photocopies of the activity page and distribute it to the learners. So they answer the activities inside their note. For the practical aspect I do more of explanation when it comes to electromagnetism because we don't have apparatus for that topic. So I just demonstrate to them using explanation method and sometimes I try using diagrams. But for electricity we can always improvise.	Teacher's improvisation skills; Teaching method; Teaching approach; No practical apparatus for electromagnetism;	Pedagogical skills and practice General pedagogical knowledge	Teachers' professional competence
The teacher believes that learners difficulties and misconceptions affects her classroom because learners don't take their time to do anything on their own as a result of	**Researcher:** How does learners' difficulties and misconceptions in this topic affect your classroom practice? **Interviewee:** Difficulties or misconceptions as you put it can only be cleared up when learners	Learners don't take time to practice Learners don't have textbook	Knowledge of learners' problem	Impact on practice

lack of resource materials such as textbooks.	take the time to practice on their own. Learners' difficulties affect my teaching because they don't have text books or workbooks to enable them do homework or practice on their own. They depend on the educator for everything from questions to solutions. So I tend to repeat some explanations over and over. I try to make sure that at least 30% to 40% of the class is able to understand what am saying before I can move to the next lesson. So I sometimes don't achieve what I plan doing, I just follow the situation in my class for the day. Despite the extra activities I give them, they still struggle to understand the concept of electromagnetism and particularly combination of series and parallel arrangement in electricity.	Learners are dependent of teachers		Teachers' professional competence
		Teacher repeats instruction often	Pedagogical skills and practice	
		Pedagogical skills		
Teacher's response indicates that parents and learners depend on the government to provide textbooks for the learners.	**Researcher:** Why don't they have text books or work books? **Interviewee:** You know these learners believe that everything is free, so they solely depend on the government for books. Although the government is giving the school books but unfortunately those books are not enough to go round the learners. You can't ask the learners to buy because their parents will come to school the next day to question us. So the absence of text books and work books to practice on their own is really affecting both the learners and we the educators.	Learners' belief	Knowledge of learners	Contextual conditions
		Parents' attitude		
		Insufficient provision from the government	Resources	

Teacher indicate the several methods she uses in addressing learners' difficulties and misconceptions.	**Researcher:** How do you address the difficulties and misconceptions that learners have in these areas? **Interviewee:** I try as much as possible to explain to the best of my knowledge and I do a lot of class activities with them. Sometimes I encourage them to solve questions individually but unfortunately there is no enough time to mark all their books. So I ensure that they exchange their books to mark as I do the correction on the board.	Teaching method; Teaching approach Explanation method Pedagogical content skill	Pedagogical skills and practice	Teachers' professional competence
Teacher's reaction indicated that she was not confident of her teaching methodology though she believes it is better.	**Researcher:** Has your method/ approach in addressing these learners' difficulties been effective? **Interviewee:** I won't really say it is effective but at least I think it is better.	Teacher's confidence	Teachers' belief	Teachers' professional competence
She believes that learners attitude to questions asked is a way of gathering evidence that learners understand the lesson being taught.	**Researcher:** How do you know that a learner has successfully overcome the difficult concept in this topics? **Interviewee:** It is simple, when learners understand a lesson you see it in their reaction, the way they answer questions and I also look at the way they interact with one another when I give them pair activities.	Learners outcome Learners understanding Learners reaction	Knowledge of learners	Teachers' professional competence

Her reaction showed that she experiences some difficulty teaching the topic electromagnetism even though her response did not admit it.	**Researcher:** As a teacher is there any concept in the area of electricity and magnetism that appears confusing or difficult to you? **Interviewee:** To be sincere with you, I still enjoy teaching math literacy than science. So as a teacher, I won't say I don't face some difficulties in this electromagnetism concept because I will say it's newly introduced in some way but sorry I won't say much about this one.	Teacher's subject interest	General pedagogical knowledge	Teachers' professional competence
She believes that teaching Physical sciences requires a lot reading as compared to teaching maths literacy	**Researcher:** You said you enjoy teaching math literacy than science, why? **Interviewee:** It's true.... when teaching math literacy, you sometimes don't need to prepare before going to class. Once you flip through the resource material you can easily understand what to teach but that is not the same for science. I have to prepare over and over before I can go to class to teach this Physical Science.	Teachers' perception about teaching maths literacy and Physical sciences.	General pedagogical knowledge	Teachers' professional competence
Her response indicated that she does not engage in teacher	**Researcher:** Do you discuss this difficult concept with your colleagues in/outside the school?	Teacher's belief		Teachers' collaboration

discussion with colleagues in and outside the school.	**Interviewee:** When I was teaching math literacy, yes I discuss with my colleagues in school and our discussion is basically on better ways or alternative approach to solving a problem but they are not really detailed. Although it's been quiet helpful talking to someone like my colleagues on some difficulties I face while teaching. Since I started teaching Physical sciences I would say not really because I have not had the opportunity to meet with other Physical sciences from other schools and the person teaching the technical section of the school is too busy with the association and other things.	No opportunity		
She believed that the way learners respond to questions asked will determine if they understand the lesson or not.	**Researcher:** You said something about 40% to 50% of learners understanding the topic, so when you are teaching, what do you look for as evidence of student learning? **Interviewee:** Basically I give the learners activities to do in form of assessment after teaching a topic, so when doing my random marking I try to take note of their performance and responses to questions. With that I am able to determine if a particular learner understands the topic or not.	Pedagogical skill Observing learners' response	Knowledge of learners General pedagogical knowledge Pedagogical skills and practice	Teachers' professional competence

Her response showed that she reflects based on the lesson missed or not covered and not based on learners learning.	**Researcher:** How and when do you reflect about your learners' difficulties in this topics? **Interviewee:** I don't reflect on a daily basis, but before my next class or lesson I try to check the curriculum and textbook again to ascertain if all the needful was taught and how I can incorporate whatever I have missed out it into my teaching to aid the learners understanding. So I can say I do my reflection after teaching a topic.	Teacher's reflection for action.	Teacher's Pedagogical practice	Teachers' professional competence
She has not attended any professional development workshop since she started teaching the subject.	**Researcher:** How often do you attend practical professional development trainings/workshops? **Interviewee:** Professional development…..In five years now I have not attended any?	Need for professional development	Professional development need of teachers	Impact on practice
She believes that the absence of a professional expert has an effect on the teachers teaching the subject.	**Researcher:** In five years………but why? **Interviewee:** The problem is from the district. We don't have a subject adviser for Physical sciences and that has been affecting me as a Physical Science educator?	Need of a professional expert	Professional development need of teachers	Impact on practice
She has not attended any professional development workshop since she started teaching the subject.	**Researcher:** That means since you started teaching Physical sciences as a subject you have never attended any professional development. **Interviewee:** exactly	Need for professional expert	Professional development need of teachers	Impact on practice
		Classroom challenges		

Teacher stated that she is left to deal with her classroom difficulties on her own.	**Researcher:** Then how do you cope with the classroom challenges and address difficulties you encounter as an educator? **Interviewee:** My sister, I am left to deal with the problem myself but sometimes I talk to my HOD and she has been of help to some extent.	Teaching challenges	Instruction management	Impact on practice
Her response showed that the challenges she is facing is as a result of the absence of professional expert (subject adviser) in the field.	**Researcher:** Wahoo.........so how has it been affecting you? **Interviewee:** I am facing problems in my class and sometimes I don't know how to resolve those problems. So I will say I am left on my own to handle situations that are beyond me which indirectly affects the learners. For example, on this topic of electromagnetism, we don't have any apparatus in my school and there is no subject adviser to help me out on other ways of teaching the practical to learners so I just verbally explain to them and continue with other aspects of the lesson. It's really hard on somebody like me but what can I do?	Teaching challenges Lack of apparatus No professional expert (subject adviser)	Instruction management No laboratory equipment Professional development need of teachers	Impact on practice
She believes that new teachers need the help of subject advisers.	**Researcher:** Why did you say it is hard on somebody like you? **Interviewee:** I said it is hard because this is my third year teaching Physical sciences. I don't have much experience, am still struggling with some aspects of the subject.	Teacher's experience Teachers' difficulty		Teachers' professional competence Impact on practice

Mbali Post Interview transcript collected 23/9/2016

Researcher's notes	Interview Questions	Codes	Sub themes	Themes
She has a perception that Lesson Study is a difficult and complicated process to carry out in schools or classes	**Researcher:** How would you describe Lesson Study? **Interviewee:** smiling……this your Lesson Study. Seriously it's a good training but it's difficult or I say the process is complicated	Teacher's perception about Lesson Study	Description of Lesson Study	Lesson Study experience
She believes that Lesson Study cannot work unless the department gives time and resources to support the program across all schools.	**Researcher:** Why did you say it's difficult or complicated? **Interviewee:** Time wena, it requires a lot of time if we really want it to work and that is not possible because I have too much to do across grade 11 and 12. I only spared you time because you are a student. More so, the planning aspect of it is just not visible as well except the department anchors it and gives us time during school hours to practice it. Hmmmmm it involves too many steps and requires a lot of thinking.	Difficulty of Lesson Study Involves a lot of thinking Requires Time Teacher's perception Teacher's workload	Challenges of Lesson Study	Lesson Study experience Contextual conditions
Teacher's response showed that she had gained a lot while participating in Lesson Study.	**Researcher:** Laughing……..thank you. So what has been your experience while participating in Lesson Study? **Interviewee:** The experience is fairly okay……it's just similar to what we normally do in our Dineledi workshops when I was still teaching math literacy. But one thing we don't do in Dineledi is to observe classroom teaching and write down whatever neither do	Teacher's experience Classroom teaching observation Collaborating with colleague	Benefits of Lesson Study Teachers' learning	Lesson Study experience

	we reflect after teaching but collaborative planning is the central point. So I will say I enjoyed collaborating with my colleague and I was able to visualize my learners' response to the intended activity. More so, the collaboration activity gave me the opportunity what my colleague knows about the topic.	Reflecting on observed teaching practice		
		Teacher's anticipation of learners' response		
Her response indicated that her ability to participate in group discussion and reflect on learners' response was more engaging to her while the time spent on collaborating together was so demanding due to her work load.	**Researcher:** What aspect of these Lesson Study process is more interesting or challenging to you? **Interviewee:** The interesting aspect of this is the group discussion because I was able to understand how to explain the direction of magnetic field on the board using my hand and problem solving aspect on magnetic flux which my partner fully explained to my understanding because I was finding it a bit confusing. I also enjoyed the aspect of reflecting on how the learners responded after leaving the class. Smiling, you know I just teach based on the curriculum and what they want us to teach but one thing I think I saw that was interesting in this your Lesson Study especially when we were planning the lesson is the ability to think about what I want my learners to know while teaching the lesson and I was able to see the importance of that thinking because a lot	Teachers' participation in group discussion	Benefits of Lesson Study	Lesson Study experience
		Increased teachers' understanding		
		Anticipating learners' response		
		Development of other teaching strategies		
		Time	Challenges of Lesson Study	

	of critical issues was raised and I was able to know why the topic should be taught and how to teach it to the learners. Like I said earlier, the challenging aspect is sitting together to do this Lesson Study. We don't have that time at all. I have too many learners and I teach grade 11 and 12. Particularly grade 12, we spend more time preparing them for the coming matric so we don't have that time to sit and plan or do all these process. Also remember am a woman, my family needs me after work. I think this training will work better in a private school and not a government school. Another interesting thing that I can say I benefited from was the ability to develop teaching approaches for the different learners especially with those slow learners.	Collaborating together		
Teacher was confident that collaborating with colleagues has helped build her confidence.	**Researcher:** Considering the collaboration aspect of this Lesson Study, how has it affected your professional knowledge and practice? **Interviewee:** it's like repeating the same thing over and over. But let me clarify this by saying that this collaboration process has really helped me to build a working and friendly relationship with my colleague and you know this tends to have a way of helping me to gradually reduce this habit of planning and teaching in isolation. Now I know that we can take any instructional risk together and definitely my understanding of some lessons is a bit upgraded.	Build working relationship	Teacher community	Teachers' collaboration
		Reducing isolation	Improved teacher attitude	
		Increased teacher's confidence		
		taking risk together		
		upgraded lesson content	Improved subject knowledge	

Teacher was confident in her response that participating in Lesson Study has helped her learn a lot about how to group learners and also manage her teaching approach.	**Researcher:** How has your participation in Lesson Study affected your teaching practice on how to address learners' difficulties in this topic? **Interviewee:** My classroom practice, hmmmmm…… a little and that is calling learners to solve questions on the board. Learners' difficulties I will say Lesson Study has helped me learn how to identify concepts that are problematic to learners based on their classroom discussions. And now I know that learners have to be properly grouped before they can make meaningful discussion amongst themselves. Now I know that I have to pick the average learners and group them with the slow ones so they can motivate one another as compared to before when I just ask them to group their selves. Hmmmmm another thing I think has changed in my practice is starting my teaching with questions and I believe calling them out to solve questions was able to build their courage. Then you know at the second class, I was able to manage the how I teach by giving detailed explanation as you explained and I think it was efficient for me because the learners' reaction to the answers showed they understood.	Increased teacher's learning Learners' participation Knowledge of learners' problem use of classroom discussion method of grouping learners teaching methodology instruction management	Improved teacher's knowledge Focus learners' learning Improved pedagogical skills and knowledge	Impact on practice
She believes that her knowledge of Mathematics has increased a bit due to her interaction with the other teacher.	**Researcher:** What is your perception about the impact of Lesson Study on your classroom practice and content knowledge? **Interviewee:** ha...Ha...Ha... This your questions are becoming too much... leboga.... Well I will say that I think I have gained a bit of the deeper Mathematics method required to solve some Physics concepts	Increase in teacher's learning (Mathematical knowledge).	Teacher's learning	Impact on practice

	especially involving parallel combination in circuits. Moreover, It has also helped me to a greater extent in bringing down this wall I have built around me when teaching this particular electromagnetism in which I don't answer some questions that learners tend to ask. I just teach and leave. Then you know I use to teach math literacy but there are some real math concepts involved in Physics which I think am gradually taking my fear away from it with the help of this collaboration process involved in Lesson Study. Then I guess I need to conclude with the fact that now I have the confidence in teaching this topic electromagnetism to my learners. I can now explain all the detail concept of how to determine the direction of fields which I do struggle with before.	Increase teacher's confidence teaching the topic	Teacher's attitude	
She believes that collaborating with her colleague during the Lesson Study has helped her to learn more about what happens in her class.	**Researcher:** Laughing **Interviewee:** One major thing I have gained in this your research is the opportunity to work together with my colleague and his input when reflecting on what he observed in my class. As an educator, I don't have all the answers to what I teach or questions asked by the learners so working with somebody outside my class I believe tends to make my job easier due to the support I know am getting from them. So I gained a lot from my colleagues' experience and now I believe that if am working with somebody or group of people who share the same classroom problem with me we are likely to see where our learners are coming from in terms of their academics and we can plan together on where they	Working together with colleague Teacher reflection	Teachers' collaboration	Lesson Study experience Impact on practice

	need to be in the future. So collaboration I will say among teachers and learners respectively is an important aspect of improving one's practice.			
Teacher's response indicated that lot of factors will not allow her to continue using Lesson Study except it becomes an intervention from the department.	**Researcher:** Are there any factors that might possibly affect your continuous use or practice of Lesson Study as a teacher? **Interviewee:** Sure sure, there are a lot of factors that will not make this work. Time is one of them like I said earlier. Our managers will not make this work too because they believe so much in us going to class to teach so giving us few minutes during the week as teachers to collaborate departmentally is sometimes a problem you know these people had their education long time ago and they still believe in their one ways of doing things forgetting that we now live in a different educational era where learning is done differently. We have told them to give teachers' opportunity to meet departmentally once a week but there was no positive response to it. Another thing I can say will not make me use this approach is I have too much of work load. This is a government school where we have a lot of Physical Science learners in the technical stream and science and commercial stream. The work load in this school is just too much and like I said earlier I also teach other subjects, so I need to plan for those subjects too. Finally, I will say the absence of a subject adviser will not make this work too. I think if we have a subject	Time factor	Resources	Contextual conditions
		Expert (specialized teacher or subject adviser);		
		Class size	Work load	
		Teacher's workload;		
		Job responsibility		
		Fear of being criticized by colleagues;	Emotions	
		School managers;	Leadership	
		Differentiated classroom situation.	Classroom environment	

	adviser, he / she will probably be informed or be aware of this kind of training and am sure she will design a program to enable us use this which am sure will be well implemented in schools if they receive direction from the department. Another reason why I said this cannot work is because some of our colleagues will over criticize your approach and turn you down, this can demoralize you as a teacher if you are not confident of yourself. Using several teaching approaches in a class where the learning difficulty of learners varies may not allow this method to work effectively**.**			
	Interviewee: We are preaching every day about this electromagnetism and current electricity to the learners we have been teaching but they seem not to know how to apply them when they see questions. **Interviewee:** we don't know whose problem this difficult concept is because I will not say it's the teacher. Immediately you introduce the topic, you hear them say it is difficult, we cannot know it. So already that preconception is there in their head that they cannot know the topic.			

Appendix 14: Lesson Study pair observation for pair A

First Group planning observation protocol	
Group Observed	Lesson Study pair A
Observer	Researcher
Topic	Electromagnetic Induction
Date	05/09/2016

Checklist for group observation

	Criteria	**Researcher's comments**
1.	Did the teachers value the contribution of one another and opened to different points of views?	Lenox was allowed to anchor the group discussion due to his years of teaching experience and position as the most senior in the group while Mbali was opened to the discussed ideas because she has little experience teaching the subject.
2.	Did the teachers demonstrate their content and pedagogical knowledge as a group while preparing for the lesson?	Yes but the lesson focus was based on what the curriculum stipulated and all resources were based on text book. No apparatus to conduct experiments.
3.	Is there collegial challenging of diverse ideas constructive criticism among the teacher during lesson planning?	During the initially proposed learners practical activity. Teachers critically discussed other methods of demonstrating the practical due to the absence of apparatus
4.	Did the teachers share responsibilities among each other?	Teachers shared responsibilities among themselves.
5.	Did the teachers identify learners' difficulties in the topic and demonstrate knowledge of learners' interest?	Teachers identified the right hand rule as one of the learners problem and was able to demonstrate how learners can effectively use the rule in identifying the direction of magnetic field and current
6.	Did the teachers effectively manage their time?	Teachers had other job responsibilities so they were always time conscious.
7.	Did the teachers monitor how they understand information and plan activities during the meeting?	They were able to ask questions from one another.

8.	Did the teachers monitor their progress and adjust their processes to become more effective in future lessons?	This was not achieved during the first meeting.
9.	Did teachers collectively set out instructional outcomes and determine learning goals during the planning session?	All outcomes were determined by the curriculum. Teachers expects that learners should be able to understand the effect of current on magnetic field and vice versa.
10.	Did the teachers consider several ways of solving learners' perceived difficulties before deciding what method works best for their class?	Due to the absence of apparatus, teachers discussed other methods that could be used in teaching the required practical activities to learners.
11.	Did the teacher design relevant instruction and learners' assessment to be used while planning the lesson?	Learning instructions and learners' assessment on this lesson were based on the practical oriented activities outlined in the work book that will be used in class.
12.	How did the teachers make connections between past learning, current goals and intended applications	Relating the topic to lessons on grade 10 magnetism and electrical circuits by revising the various basic vocabularies.

Second Group planning observation protocol	
Group Observed	Lesson Study pair A
Observer	Researcher
Topic	Magnetic flux and Faraday's Law
Date	09/09/2016

	Criteria	**Researchers comments**
1.	Did the teachers value the contribution of one another and opened to different points of views?	Both teachers agreed to Lenox explanation on how to introduce the lesson to learners and Mbali's idea of using of several problem solving approaches.

2.	Did the teachers demonstrate their content and pedagogical knowledge as a group while preparing for the lesson?	Both teachers were able to come up with methods of explaining how magnetic field in a solenoid changes when a magnet is inserted or extracted from the solenoid.
3.	Is there collegial challenging of diverse ideas constructive criticism among the teacher during lesson planning?	Criticism was based on the use of approach illustration that could further enhance learners understanding and imagination of magnetic field in a solenoid.
4.	Did the teachers share responsibilities among each other?	Teachers worked as a team by sharing responsibilities among themselves. Lenox wrote the lesson plan while Mbali sketched the overall goal of the lesson.
5.	Did the teachers identify learners' difficulties in the topic and demonstrate knowledge of learners' interest?	Mbali indicated that learners have difficulties with problem solving questions. Lenox on the identified learners' inability to visualize what the teacher is teaching.
6.	Did the teachers effectively manage their time?	Teachers finished their group planning on time because they had other classes and responsibilities to take.
7.	Did the teachers monitor how they understand information and plan activities during the meeting?	Lenox suggestion and explanation on how learners can understand the relationship between a magnetic flux and magnetic field was elaborately considered as one of the class examples to be used.
8.	Did teachers monitor their progress and adjust their processes to become more effective in future lessons?	Mbali commented on improving on her class management and discipline skills for future lessons while Lenox identified the need to call out learners to solve problems on the board as a way of improving his teaching practice.
9.	Did teachers collectively set out instructional outcomes and determine learning goals during the planning session?	Learning outcomes were aligned with the curriculum and text resources. Learners should have

10.	Did the teachers consider several ways of solving learners' perceived difficulties before deciding what method works best for their class?	Teachers planned several worked examples but did not agree on any form of method that best suits the learners. However, teachers lots of examples to enhance learners understanding.
11.	Did the teacher design relevant instruction and learners' assessment to be used while planning the lesson?	Instructions and learners assessment were based on learners workbook and textbook.
12.	How did the teachers make connections between past learning, current goals and intended applications	The team agreed that learners must basic scientific knowledge like the right hand rule, how to determine a magnetic field and application of simple Mathematical calculations.

Third Group planning observation protocol	
Group Observed	Lesson Study pair A
Observer	Researcher
Topic	Electrical Circuits
Date	15/09/2016

Checklist for group observation

	Criteria	**Researcher's comments**
1.	Did the teachers value the contribution of one another and opened to different points of views?	Teachers allowed one another to explain their understanding of how learners make mistakes when solving problems on circuit arrangement. For instance Lenox stated that learners forget the inverse signs when solving parallel connections and Mbali stated that learners get stuck with identifying directions of current and voltage in a parallel circuit.

2.	Did the teachers demonstrate their content and pedagogical knowledge as a group while preparing for the lesson?	Teachers demonstrated adequate knowledge of content and pedagogy by solving several questions based on past learners' examination questions and suggesting better ways of explaining such concepts to learners. Lenox particularly stated that learners will be advised to always solve for series connection before the parallel in cases where they are asked to solve problems on combination circuit.
3.	Is there collegial challenging of diverse ideas constructive criticism among the teacher during lesson planning?	Teachers probed each other's ideas on the different approaches that can be used in solving problems on parallel arrangement and still arriving at the same answer.
4.	Did the teachers share responsibilities among each other?	Teachers worked as a team by sharing responsibilities amongst themselves. Lenox agreed to write the Lesson Study plan to be used by the group as the discussion continues while Mbali agreed to sketch the overall goals of the lesson to be taught as the group continues with their planning.
5.	Did the teachers identify learners' difficulties in the topic and demonstrate knowledge of learners' interest?	Teachers' discussions was centred on learners' difficulties in solving problems on parallel circuit and combination of circuit.
6.	Did the teachers effectively manage their time?	Teachers were efficient and worked within time limit because they have other responsibilities assigned in the school
7.	Did the teachers monitor how they understand information and plan activities during the meeting?	Teachers basically asked questions on how their previous class teaching went and what they can do to make the teaching more effective.

8.	Did teachers monitor their progress and adjust their processes to become more effective in future lessons?	Teachers asked themselves questions on what their learners should know, how they should ask questions and what they expect from the learners. Teachers reflected on their professional knowledge by solving several examples they intend to use as class activity for learners.
9.	Did teachers collectively set out instructional outcomes and determine learning goals during the planning session?	The team agreed that learners should be able to calculate voltage, current and resistor in both series and parallel circuit connection; as well as in combined circuits.
10.	Did the teachers consider several ways of solving learners' perceived difficulties before deciding what method works best for their class?	Teachers did not really plan on using several approaches. They agreed to use the best method that appears meaningful to them. More so, teachers was able to critically think and discuss how learners will respond to the class activities.
11.	Did the teacher design relevant instruction and learners' assessment to be used while planning the lesson?	Learning instructions and learners' assessment were based on what the curriculum stipulated. Teachers planned to connect learners' previous knowledge to the new lesson and future applications by asking relevant questions.
12.	How did the teachers make connections between past learning, current goals and intended applications	Connection to current goals: Teachers planned to involve learners in group activities (e.g. they agreed to put learners in group to perform a simple experiment and to report their observation as a group to the class) in order to enhance meaningful teaching of the lesson.

Appendix 15: Lesson Study lesson plans prepared by pair A

Lesson Study: **Lesson Plan on research lesson 1**

Name of School: Constant High School **Lesson duration**: 40 minutes

Date: 05/09/2016 **Grade:** 11

Subject: Physical sciences

Topic: Magnetic field

<table>
<tr><td colspan="2">What is the importance of this topic to the learners?</td></tr>
<tr><td colspan="2">Resources: Bar magnets, coil/solenoid, conducting wires, galvanometer, electric circuit board, compasses
Material and Apparatus:Text book, workbook
What is the teaching model/ approach you will use for this lesson? Explanation, self -discovery based on alternative to practical approach.</td></tr>
<tr><td colspan="2">What are your Goal(s) / Objective(s) for this lesson?
Understanding of the influence of electric current on magnetic field and vice versa</td></tr>
<tr><td colspan="2">What should learners already know (previous knowledge)?
Understanding off electrical circuit vocabulary and magnetism</td></tr>
<tr><td colspan="2">What should learners know after this lesson?
How to identify direction of current and magnetic field using the Right hand rule</td></tr>
<tr><td colspan="2">What are the vocabulary terms associated with this topic?
Electric current, magnetic field, solenoid, Right hand rule</td></tr>
<tr><td colspan="2">Lesson Introduction:
• Learners will be taught how magnetic field are induced in a solenoid using compasses.
• Learners will be taught how current is induced when a magnet enters a solenoid.</td></tr>
<tr><td>Learners' class activity</td><td>Teachers 'expectation of learners' response</td></tr>
<tr><td>• Learners will do an alternative to practical based on their work books to determine what happens when of a bar magnet enters and exits a solenoid connected to a galvanometer.
• Learners will determine the direction of induced current in a coil as indicated in their work book.</td><td>Learners are to write down the rules and laws they use in determining the direction of induced current and induced magnetic field in their work book.</td></tr>
<tr><td colspan="2">Closing (How do you wrap up /conclude the lesson):</td></tr>
</table>

Learners understanding of the right hand rule will be tested verbally

Teacher's Feedback to learners about the class activity (in terms of correction):

No feedback will be given unless a misconception is identified. Knowledge from the alternative to practical will be well explained and used as a prior knowledge for the next lesson.

Home work:

No homework will be given for this lesson.

Teachers reflection on the lesson taught:

Learners understanding increases with alternative to practical exposure to the topic. Although practical is time consuming and the school does not have apparatus to conduct life practical on electromagnetism.

Lesson Study: Lesson Plan on research lesson 2

Name of School: Constant High School **Lesson duration**: 40 minutes

Date: 09/09/2016 **Grade**: 11

Subject: Physical sciences

Topic: Faraday's Law of electromagnetic induction

What is the importance of this topic to the learners?

Topic forms basis to understanding motors and generators in grade 12.

Resources: Physics Textbook/Workbook, Answer series CAPS grade 11

Material and Apparatus: Galvanometer, 3 different coils (change in number of loops), Bar magnet

What is the teaching model/ approach you will use for this lesson? Instruction and explanation,

What are your Goal(s) / Objective(s) for this lesson?

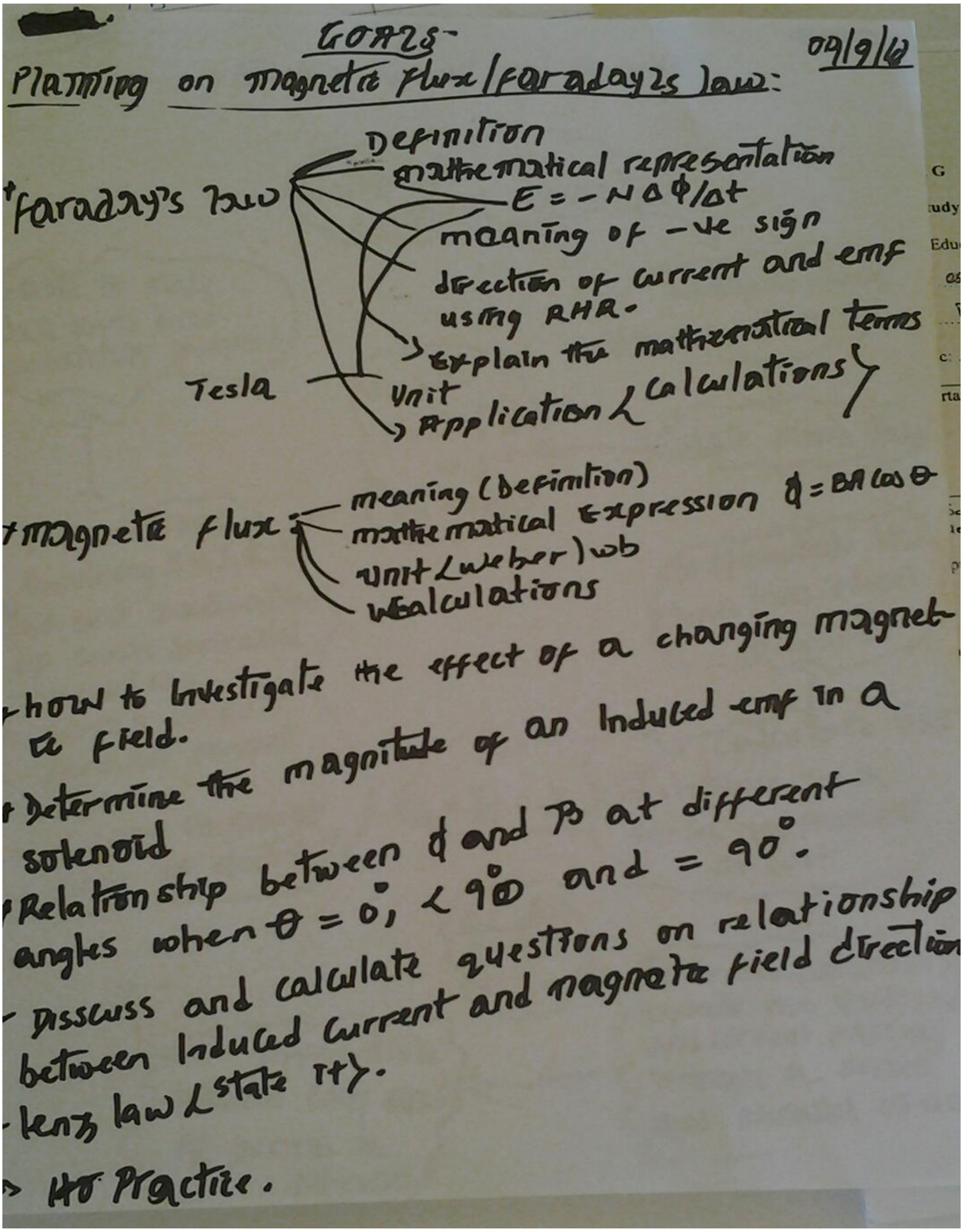
- Learners should be able to use the right hand rule to determine current in a solenoid/magnetic field induced by current.
- Understand that magnetic field in a solenoid changes when a magnet is inserted or extracted from a solenoid
- Brief understanding of magnetic flux and Faraday's law.

What should learners already know (previous knowledge)?

- Magnetic field
- Right hand rule
- Emf
- Time/rate
- Area calculations
- Components (perpendicular)

What should learners know after this lesson? • That magnetic field induced in a solenoid is dependent on what pole of the magnet enters the solenoid/exits the solenoid. • That it always opposes the magnetic field that enters /is extracted from the coil.	
What are the vocabulary terms associated with this topic? Magnetic field strength, Magnetic flux linkage, Rate of change in magnetic flux, Windings, Emf, Tesla, weber, Area	
Lesson Introduction: Discussion of learners' questions based on alternative to practical in previous lesson forms the link between alternating magnetic field in a coil which is caused by magnets moving into or out of a coil.	
Learners' class activity	**Teachers 'expectation of learners' response**
• Learners to calculate examples given by teacher. • Homework DS Ex 18 no 1, 2 and 5	• Learners should use right hand rule to determine direction of current in a coil • Homework • Participate in resolving problems (example)
Closing (How do you wrap up /conclude the lesson): Determine if any misconceptions are formed and eliminate.	
Teacher's Feedback to learners about the class activity (in terms of correction): Will give feedback while discussing homework questions and in duration of lesson answer questions.	
Home work: Doc Scientia pg. 250 Ex 18 no 1, 2 and 5.	
Teachers reflection on the lesson taught: Learners tend to ask questions which is part of the lesson but not yet arrived at.	

Summary of Lesson Goals on Lesson 2 prepared by Pair A



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GOALS

Planning on magnetic flux/Faraday's law: 09/9/16

*Faraday's law
- Definition
- mathematical representation
  - $E = -N\Delta\phi/\Delta t$
- meaning of –ve sign
- direction of current and emf using RHR.
- explain the mathematical terms
- Unit — Tesla
- Application (calculations)

*magnetic flux:
- meaning (Definition)
- mathematical Expression $\phi = BA\cos\theta$
- unit (weber) wb
- calculations

- how to investigate the effect of a changing magnetic field.
- Determine the magnitude of an induced emf in a solenoid
- Relationship between ϕ and B at different angles when $\theta = 0°$, $< 90°$ and $= 90°$.
- Discuss and calculate questions on relationship between induced current and magnetic field direction
- Lenz law (state it).

> HW Practice.

Lesson Study: Lesson Plan on research lesson 3

Name of School: Constant High School **Lesson duration:** 40 minutes

Date: 15/09/2016 **Grade:** 11

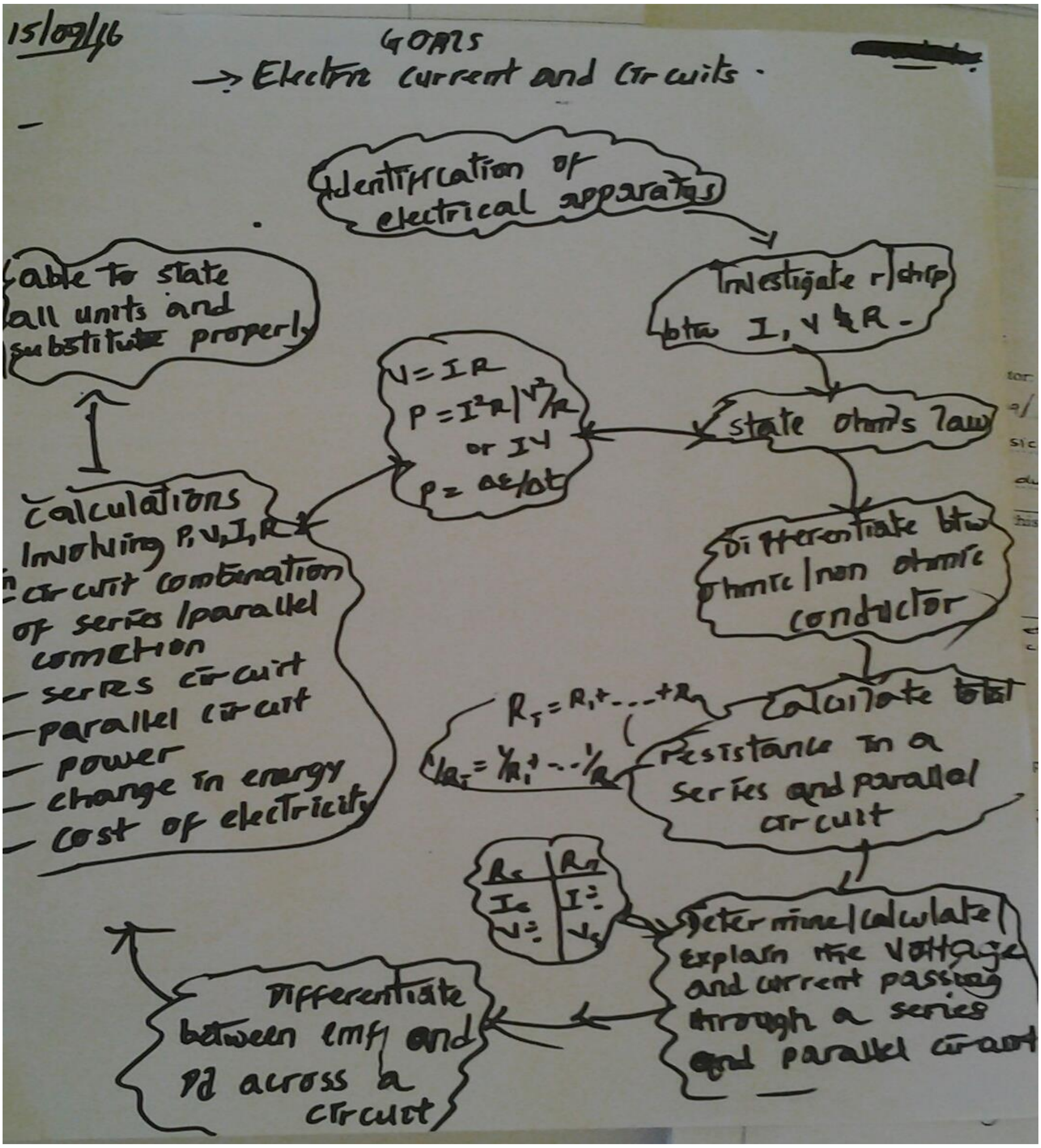
Subject: Physical sciences

Topic: Electric Circuit (series and parallel combination circuits)

<table>
<tr><td colspan="2">What is the importance of this topic to the learners?
Learners should be able to calculate V; I; R in both types of circuit as well as circuits where series and parallel connections are combined</td></tr>
<tr><td colspan="2">Resources: Textbook
Material and Apparatus: circuit board, cells, ammeter, voltmeter, light bulb.
What is the teaching model/ approach you will use for this lesson? Discovery, Demonstration</td></tr>
<tr><td colspan="2">What are your Goal(s) / Objective(s) for this lesson?
Learners should be able to use knowledge of the different types of circuits to accurately calculate potential difference, current and resistance in combine in circuit diagrams</td></tr>
<tr><td colspan="2">What should learners already know (previous knowledge)?
Knowledge of series and parallel circuits, its current, potential difference and resistance.</td></tr>
<tr><td colspan="2">What should learners know after this lesson?
How to calculate potential difference, current and total resistance of a combined circuit.</td></tr>
<tr><td colspan="2">What are the vocabulary terms associated with this topic?
Potential difference, current, resistance in parallel and series.</td></tr>
<tr><td colspan="2">Lesson Introduction:
Discussion of potential difference in a series and parallel circuit; as well as current and resistance.</td></tr>
<tr><td>Learners' class activity</td><td>Teachers 'expectation of learners' response</td></tr>
<tr><td>Draw a table to compare differences between series and parallel circuits.
Problem solving on combination of circuits</td><td>Learners should have very good understanding of how current and resistance works in each type of circuit.
Effectively differentiate between parallel and series formula when calculating.</td></tr>
<tr><td colspan="2">Closing (How do you wrap up /conclude the lesson):
Example of combination circuits are done with learners (focus on resistance).</td></tr>
<tr><td colspan="2">Teacher's Feedback to learners about the class activity (in terms of correction):
Learners receive feedback during discussion of problems in the exercise.</td></tr>
<tr><td colspan="2">Home work:
Ex 19</td></tr>
</table>

Teachers reflection on the lesson taught: Learners have a good knowledge of current, resistance and potential difference in both series and parallel circuits from grade 10.

Summary of Lesson Goals on Lesson 3 prepared by Pair A



Appendix 16: Classroom observation transcript from Lesson Study pair A

Appendix 16A: Lenox's observation schedule

Lenox's observation schedule for lesson 1

School	Constant high school
Date of lesson observation	September 06, 2016
Subject	Physical sciences
Grade	11T
Number of learners	60
Topic Observed	Induced current and Induced magnetic fields
Lesson time	10:25 – 11:10

Checklist for teacher's classroom lesson observation

Observed Element	**Criteria**	**Evidence**
Assessing learners learning	Did the teacher assess learners' previous knowledge?	He asked the learners to define magnets and state the properties of a magnet.
	Did the teacher check for learners understanding of the lesson taught?	By verbally asking questions
Instructional delivery	Did the teacher present an overview of the lesson?	He narrated the future knowledge that learners will gain after bringing electric current near a magnetic material.
	Did the teacher manage the disruptive behaviours of learners?	Lenox kept the learners attentive all the time
	Did the teacher engage the learners in a whole class activity?	Lenox did not engage the learners in class activity but in a class discussion based on his explanation.
	Did the teacher present the lesson to meet the planned objectives?	Content of learning activities supported the planned lesson objectives

	Did the teacher clarify learners' misconceptions during the teaching?	He clarified learners' challenges when he demonstrated the concept of in page and out of page.
	Did the teacher demonstrate knowledge of various teaching practices?	he used more of lecture presentation, explanation and relevant examples from the text book
	Did the teacher integrate examples from real world into the teaching?	Not achieved in this lesson
	Did the teacher emphasize important points while teaching?	Not achieved in this lesson
	Teacher use relevant activities to clarify key concepts?	Yes, activities from textbook and learners workbook.
Classroom interaction	Did the teacher encourage small group/ paired activities among learners?	Not accomplished in this lesson
	Did the teacher encourage individual /independent work among learners	Yes, he asked each learner to demonstrate the concept of in page and out of page using their thumb
	Did the teacher write key terms on the board?	He used key words to explain basic concepts
	What lecturing activities did the teacher use in disseminating knowledge?	Explanations, stating facts based on his own content knowledge.
	Did the teacher create a good classroom environment for teaching the lesson?	Maintained silent environment and used diverse strategies to enhance learners understanding.
	Did the teacher relate well with the learners?	Teacher listened carefully to learners' questions
	Was the teacher able to support learners learning?	He encouraged learners to attempt class activity and also went round to mark class activities
	Did the teacher encourage learners to participate in the teaching and learning process?	He encouraged the learners by showing his communication skill and building good rapport with the learners
	Teacher effectively manage the classroom.	He managed the classroom by displaying energy and enthusiasm

	Did teacher create an environment of interest for learners while teaching this lesson?	He established an environment of interest by demonstrating flexibility in his teaching using both English and Setswana to enhance learners understanding.
Teacher's knowledge	Did the teacher demonstrate knowledge of required concepts in the subject matter?	Lenox presented the lesson content directly from the textbook
	Did the teacher conduct practical activities?	No practical activity was conducted in this lesson
	Was the content of the lesson presented to meet learners need?	He logically presented and paced the lesson and did not engage learners in the required practical activities.
	Is the teacher committed and enthusiastic about the lesson and learners learning	Lenox showed commitment in his teaching even though he was not confident.
	Did the teacher show empathy towards learners' inability to understand the lesson?	He was able to re explain some concepts and this shows that he was concerned about the learners' ability to understand the lesson.
	Is the teacher able to provide learners with accurate feedback?	He did not give any form of feedback to learners in this lesson.

Lenox observation schedule for lesson 2

School	Constant high school
Date of lesson observation	September 12, 2016
Subject	Physical sciences
Grade	11T
Number of learners	60
Topic Observed	Magnetic flux and Faraday's law
Lesson time	11:30 – 12:05

Checklist for teacher's classroom lesson observation

Observed Element	**Criteria**	**Evidence**

Assessing learners learning	Did the teacher assess learners' previous knowledge?	He only revised previous lesson with the learners
	Did the teacher check for learners understanding of the lesson taught?	His ability to check for learners understanding in this lesson was observed when he asked questions through the class activities
Instructional delivery	Did the teacher present an overview of the lesson?	This was observed when he stated that the purpose of the lesson was to determine the strength of a magnetic field, solve problems on magnetic flux and Faraday's law
	Did the teacher manage the disruptive behaviours of learners?	Lenox was always keeping the learners attentive by giving them strict instructions before starting his teaching.
	Did the teacher engage the learners in whole class discussion?	He asked the learners to open their photocopied textbook page, read a particular activity and explain an activity.
	Did the teacher integrate examples from real world into the teaching?	Not accomplished in this lesson.
	Did the teacher present the lesson to meet the planned objectives?	The lesson was presented to meet the planned objectives when he demonstrated his own pedagogical skills in disseminating the planned lesson to learners.
	Did the teacher clarify learners' misconceptions during the teaching?	This was observed when a learner asked for the meaning of the negative sign on the Mathematical representation of the Faraday's law and he re explained by indicating the meaning of the negative sign as direction of current.
	Did the teacher demonstrate knowledge of various teaching practices?	Yes, question and answer, explanation, problem solving activities, learners' participation, use of white board.
	Did the teacher emphasize important points while teaching?	He emphasized on the application of Faraday's law which shows the relationship between induced electromotive force and the rate of change of flux.
	Teacher use relevant activities to clarify key concepts.	He used several examples to enhance learners understanding of the problem solving aspect.
Classroom interaction	Did the teacher encourage small group/ paired activities among learners?	Teacher did not encourage small group activities among learners in this lesson

	Did the teacher encourage individual /independent work among learners	Individual activities among learners was observed in this lesson when Lenox gave the learners problem solving activities on Faraday's law.
	Did the teacher write key terms on the board?	He only wrote important formula on the board.
	What lecturing activities did the teacher use in disseminating knowledge?	Learners' participation, classroom management, ability to address learners' misconception, providing feedback to learners
	Did the teacher create a good classroom environment for teaching the lesson?	Yes, by encouraging learners who got the answers correctly
	Did the teacher relate well with the learners?	Learner teacher relationship was evident during the teaching process.
	Did the teacher support learners learning?	Yes, by appropriately responding to learners' questions.
	Did the teacher encourage learners to participate in the teaching and learning process?	By asking questions and applauding them whenever they respond to questions.
	Did the teacher effectively manage the classroom?	Yes, when he saw some learners talking during the class activity and he interfered in their discussion
	Did the teacher create an environment of interest for learners while teaching this lesson?	Yes, because he showed evidence of celebrating learners correct answers
Teacher's knowledge	Did the teacher demonstrate knowledge of required concepts in the subject matter?	Lesson content was presented and explained in detail
	Did the teacher conduct practical activities?	He simulated the application of Faraday's law using his right hand.
	Was the content of the lesson related to learners' previous knowledge?	He revised previous lesson and linked it to new lesson.
	Is the teacher committed and enthusiastic about the lesson and learners learning	He was enthusiastic and committed because he used several examples to enhance learners understanding.
	Did the teacher show empathy towards learners' inability to understand the lesson?	He clarified learners understanding by giving brief explanation of each terminologies used in Faraday's law
	Did the teacher provide learners with accurate feedback?	He solved provided answers to some class activities on the board when learners could not provide the right answers

Lenox's observation schedule for lesson 3

School	Constant high school
Date of lesson observation	September 19, 2016
Subject	Physical sciences
Grade	11T
Number of learners	60
Topic Observed	Electric circuits
Lesson time	10:00 – 10:45

Checklist for teacher's classroom lesson observation

Observed Element	**Criteria**	**Evidence**
Assessing learners learning	Did the teacher assess learners' previous knowledge?	Yes, he asked the learners to state Ohm's law.
	Did the teacher check for learners understanding of the lesson taught?	This was observed when he drew a circuit diagram on the board and asked the learners to re-arrange the diagram.
Instructional delivery	Did the teacher present the lesson to meet the planned objectives?	Lesson was not fully aligned to planned objective because he did not conduct the practical illustrated during the group planning.
	Did the teacher clarify learners' misconceptions during the teaching?	By explaining the difference between potential difference and electromotive force
	Did the teacher demonstrate knowledge of various teaching practices?	He used lecture presentation, explanation, question and answer, learners' previous knowledge, learners' participation.
	Did the teacher present the lesson to meet the planned objectives?	Lesson was not fully aligned to planned objective because he did not conduct the practical illustrated during the group planning.
	Did the teacher clarify learners' misconceptions during the teaching?	By explaining the difference between potential difference and electromotive force
	Did the teacher demonstrate knowledge of various teaching practices?	He used lecture presentation, explanation, question and answer, learners' previous knowledge, learners' participation.

	Did the teacher integrate examples from real world into the teaching?	He used life applications of the electricity consumed by learners in their respective houses to aid his explanation.
	Did the teacher emphasize important points while teaching?	He emphasized that learners must know the definition of Ohm's law because it is paramount to their understanding of will be done in electricity.
	Teacher use relevant activities to clarify key concepts.	Explanation, diagram, tabular representation, problem based learning,
Classroom interaction	Did the teacher encourage small group/ paired activities among learners?	No group or paired activities was used in his class.
	Did the teacher encourage individual /independent work among learners	He dictated question from his personal note and asked all the learners to attempt the question.
	Did the teacher engage the learners in whole class discussion?	He used a teacher directed question when he asked learners to give examples of equipment that consumes electricity in their respective homes.
	Did the teacher write key terms on the board?	Yes, he used a table to present the concept of resistance in series and parallel on the corner of the board.
	What lecturing activities did the teacher use in disseminating knowledge?	He used explanation and also presented facts about the application of electricity in real life situations.
	Did the teacher create a good classroom environment for teaching the lesson?	Learners demonstrated mutual respect for the teacher and the classroom environment was quiet and conducive for teaching.
	Did the teacher relate well with the learners?	He explained some concepts in Setswana and later translated in English. Learners also responded in both Setswana and English.
	Did the teacher support learners learning?	He supported learners learning by using their response as a guide to providing the correct answers to questions asked.
	Did the teacher encourage learners to participate in the teaching and learning process?	By asking those questions that promoted learners problem-solving skills and motivating learners to answer questions.
	Did the teacher effectively manage the classroom?	Learners already understand their teacher's behavioural expectation. So the class was well managed.

	Did the teacher create an environment of interest for learners while teaching this lesson?	Lenox created an opportunity for learners to share their answers, ideas, and knowledge with one another.
Teacher's knowledge	Did the teacher demonstrate knowledge of required concepts in the subject matter?	This was confirmed when he said voltage divides and current remains the same for resistance in series while voltage remains the same as current divides across the resistor in parallel connection.
	Did the teacher conduct practical activities?	Practical activities was required but not conducted in his class.
	Was the content of the lesson related to learners' previous knowledge?	Lesson content was related to learners' grade 10 knowledge of resistors in series and parallel.
	Is the teacher committed and enthusiastic about the lesson and learners learning	He was enthusiastic about learners learning when he showed learners how to re- arrange complex circuit into single circuit.
	Did the teacher show empathy towards learners' inability to understand the lesson?	He was concerned about learners' ability to interpret questions and solve problems on parallel arrangements. So he had to re teach the concept again.
	Did the teacher provide learners with accurate feedback?	He solved questions from class activity on the board and explained the step by step process of obtaining the answers to learners.

Appendix 16B: Mbali's observation schedule

Mbali observation schedule for lesson 1

School	Constant high school
Date of lesson observation	September 08, 2016
Subject	Physical sciences
Grade	11C
Number of learners	54
Topic Observed	Induced current and Induced magnetic fields
Lesson time	11:30 – 12:10

Checklist for teacher's classroom lesson observation

Observed Element	**Criteria**	**Evidence**
Assessing learners learning	Did the teacher assess learners' previous knowledge?	She asked the learners to define a magnet and also state the different types of magnet.
	Did the teacher check for learners understanding of the lesson taught?	Orally asking questions
Instructional delivery	Did the teacher present an overview of the lesson?	She explained how the interaction between current, charges, electric field and magnetic field is established.
	Did the teacher manage the disruptive behaviours of learners?	No because the learners were disobedient and uncontrollable.
	Did the teacher engage the learners in whole class discussion?	Not achieved in this lesson
	Did the teacher present the lesson to meet the planned objectives?	She deviated a bit from the planned lesson.
	Did the teacher clarify learners' misconceptions during the teaching?	Learners did not ask question, so teacher could give clarity on questions not asked.
	Did the teacher demonstrate knowledge of various teaching practices?	She used explanation, lecture presentation

	Did the teacher integrate examples from real world into the teaching?	Not achieved
	Did the teacher emphasize important points while teaching?	She did no define key points but used various examples to clarify key concepts
	Teacher use relevant activities to clarify key concepts.	She used activities from textbook and learners work book
Classroom interaction	Did the teacher encourage small group/ paired activities among learners?	Not achieved in this lesson.
	Did the teacher encourage individual /independent work among learners	By giving class activities
	Did the teacher write key terms on the board?	Not accomplished in this lesson.
	What lecturing activities did the teacher use in disseminating knowledge?	Explanation
	Did the teacher create a good classroom environment for teaching the lesson?	Classroom was noisy
	Did the teacher relate well with the learners?	Lesson was basically teacher centred
	Did the teacher support learners learning?	By reinforcing the importance of the right hand rule.
	Did the teacher encourage learners to participate in the teaching and learning process?	By asking question and telling them to raise their hands if they know the answer.
	Did the teacher effectively manage the classroom?	Not accomplished because learners were disruptive.
	Did the teacher create an environment of interest for learners while teaching this lesson?	No because she could not address the learners negative behaviour.
Teacher's knowledge	Did the teacher demonstrate knowledge of required concepts in the subject matter?	By explaining and presenting the correct required content. Though she looks nervous while teaching.
	Did the teacher conduct practical activities?	No practical activity was conducted
	Was the content of the lesson related to learners' previous knowledge?	Yes, by linking learners knowledge of magnets to electric field and charges.
	Is the teacher committed and enthusiastic about the lesson and learners learning	She showed commitment and enthusiasm when she explained the deflection of a galvanometer if connected to a solenoid

	Did the teacher show empathy towards learners' inability to understand the lesson?	She showed no empathy because she did not encourage the learners to ask question
	Did the teacher provide learners with accurate feedback?	Class activities were not marked, so no feedback was given to learners.

Mbali observation schedule for lesson 2

School	Constant high school
Date of lesson observation	September 14, 2016
Subject	Physical sciences
Grade	11C
Number of learners	54
Topic Observed	Magnetic field strength, magnetic flux and Faraday's law
Lesson time	12:00 – 12:40

Checklist for teacher's classroom lesson observation

Observed Element	**Criteria**	**Evidence**
Assessing learners learning	Did the teacher assess learners' previous knowledge?	By engaging them in a teacher directed question and answer section
	Did the teacher check for learners understanding of the lesson taught?	She verbally asked questions and encouraged learners activities
Instructional delivery	Did the teacher present an overview of the lesson?	This was not achieved probable because the teacher was carried away with the lesson.
	Did the teacher manage the disruptive behaviours of learners?	Not achieved even though she clearly stated that she will reprimand the learners.
	Did the teacher engage the learners in whole class discussion?	Not observed

	Did the teacher present the lesson to meet the planned objectives?	Yes, teacher's outlined lesson goals was achieved.
	Did the teacher clarify learners' misconceptions during the teaching?	Yes, when she explained that the negative sign in Faraday's law indicates the direction of induced Emf
	Did the teacher demonstrate knowledge of various teaching practices?	She used words, diagrams, explanation, learners demonstration, problem based learning.
	Did the teacher integrate examples from real world into the teaching?	Yes, when she used her right hand to demonstrate the right hand rule.
	Did the teacher emphasize important points while teaching?	She told the learners that the direction of currents and associated magnetic fields can only be determined using the Right Hand Rule
	Did the teacher use relevant activities to clarify key concepts?	All activities were from the textbook and learners work book.
Classroom interaction	Did the teacher encourage small group/ paired activities among learners?	Not accomplished in this lesson.
	Did the teacher encourage individual /independent work among learners	She gave the learners class activities
	Did the teacher write key terms on the board?	She wrote E= -N $^{\Delta\phi}/\Delta t$ on the board.
	What lecturing activities did the teacher use in disseminating knowledge?	She basically explained all her lesson and later asked learners few questions.
	Did the teacher create a good classroom environment for teaching the lesson?	positive learner-teacher relationship was evident even though the learners were disrespectful
	Is the teacher able to relate well with the learners?	No because she did not give learners time to respond to questions.
	Did the teacher support learners learning?	She actively encouraged learners to participate in the teaching process.
	Did the teacher encourage learners to participate in the teaching and learning process?	When she called out some learners to practically demonstrate the concept of induced current around a conductor moving in a circular direction with their right hand using a paper
	Did the teacher effectively manage the classroom?	Not accomplished

	Did teacher create an environment of interest for learners while teaching this lesson?	By actively encouraging learners participation in the teaching process.
Teacher’s knowledge	Did the teacher demonstrate knowledge of required concepts in the subject matter?	She presented the lesson explicitly and correctly as planned; also read directly from the text book.
	Did the teacher conduct practical activities?	No practical activities conducted but rather simulations based on the application of Faraday’s law.
	Was the content of the lesson related to learners’ previous knowledge?	Learners’ demonstration of the application of right hand rule was used to introduce the concept of Faraday’s law.
	Is the teacher committed and enthusiastic about the lesson and learners learning	She enjoyed the calculation aspect of the lesson and was committed to learners learning by constantly asking if they understood.
	Did the teacher show empathy towards learners’ inability to understand the lesson?	She used oral questions to check learners understanding and she constantly ask the learners if they understood what she was teaching.
	Is the teacher able to provide learners with accurate feedback?	She corrected the learners by explaining that the negative sign indicates the direction of the induced Emf

Mbali observation schedule for lesson 3

School	Constant high school
Date of lesson observation	September 21, 2016
Subject	Physical sciences
Grade	11C
Number of learners	54
Topic Observed	Electric circuits
Lesson time	11:30 – 12:10

Checklist for teacher’s classroom lesson observation

Observed Element	**Criteria**	**Evidence**

Assessing learners learning	Did the teacher assess learners' previous knowledge?	She asked questions on the different types of electricity and what is meant by static electricity
	Did the teacher check for learners understanding of the lesson taught?	This was observed when she asked learners to state Ohm's law and explain the relationship between V and R.
Instructional delivery	Did the teacher present an overview of the lesson?	She presented an overview of the lesson when she told the learners that the lesson is focused on teaching them how to arrange and solve questions related to series and parallel arrangement.
	Did the teacher manage the disruptive behaviours of learners?	Yes, this was observed when she asked the learners to control their noise and instructed them to always indicate by raising their hand whenever they want to answer any question.
	Did the teacher engage the learners in whole class discussion?	Learners participated in whole class discussion through teachers guided instruction on how to connect circuits in series and parallel.
	Did the teacher present the lesson to meet the planned objectives?	Mbali's lesson was presented to meet the Lesson Study team planned objectives.
	Did the teacher clarify learners' misconceptions during the teaching?	She clarified learners' difficulties by explaining what happens to the current and voltage of a resistor connected in series and parallel using a tabular form.
	Did the teacher demonstrate knowledge of various teaching practices?	She demonstrated her knowledge and skills in teaching with the use of inquiry oriented teaching practices that were appropriate for her learners.
	Did the teacher integrate examples from real world into the teaching?	Mbali did not use examples from real life experience to enhance her lesson delivery.
	Did the teacher emphasize important points while teaching?	This was observed when she drew a tabular representation summarizing the effect of current and voltage in a series and parallel connection and further explained the concept to learners.
	Did teacher use relevant activities to clarify key concepts?	She defined unfamiliar terms, explained major and minor learners difficulties and also used relevant class activities to clarify key concepts
Classroom interaction	Did the teacher encourage small group/ paired activities among learners?	Group activities was observed in this lesson when learners were performing hands on practical activity on circuit connection.

	Did the teacher encourage individual /independent work among learners	Individual activities among learners was observed when the teacher asked learners to attempt a specific class activity in the photocopied page after the teacher's worked example.
	Did the teacher write key terms on the board?	This was not observed in this lesson.
	What lecturing activities did the teacher use in disseminating knowledge?	She used discovery learning, interactive demonstration, and problem based learning to enhance learners understanding of the lesson.
	Did the teacher create a good classroom environment for teaching the lesson?	She controlled learners' noise and provided practical support for learners' academic needs.
	Did teacher relate well with the learners?	Mbali was able to use verbal activities to enhance her lesson teaching and learners promptly responded to their teacher's questions.
	Did the teacher support learners learning?	She supported learners learning by engaging the learners in a practical session and also encouraged learners to always substitute correctly when solving problems.
	Did the teacher encourage learners to participate in the teaching and learning process?	Mbali encouraged learners' participation in the teaching and learning process by constantly calling learners out to solve questions on the board.
	Did the teacher effectively manage the classroom?	The classroom was effectively managed.
	Did the teacher create an environment of interest for learners while teaching this lesson?	She was able to address the learners negative behaviour and she tried reinforcing their positive behaviours by involving them in several activities
Teacher's knowledge	Did the teacher demonstrate knowledge of required concepts in the subject matter?	Mbali demonstrated accurate knowledge of subject matter by clearly presenting content on current and voltage across a series and parallel connection. She also correctly explained the content on difference between electromotive force and potential difference across a circuit.
	Did the teacher conduct practical activities?	The teacher engaged the learners in practical activity.
	Was the content of the lesson related to learners' previous knowledge?	She asked question on learners' grade 10 knowledge about static electricity and later indicated that now they will be focusing on current electricity.

	Is the teacher committed and enthusiastic about the lesson and learners learning	Mbali showed interest in the lesson as she constantly checked learners' ability to understand the lesson.
	Did the teacher show empathy towards learners' inability to understand the lesson?	This was noted when the teacher re explained the concept of resistors connected in series and parallel using a tabular representations when she observed that learners were still finding it difficult to understand how current and voltage divides in both circuit connection.
	Did the teacher provide learners with accurate feedback?	Mbali provided correction to learners' class activities on the board.

Appendix 17: Document Analysis of Lesson Study pair A

Teacher' Pseudonym: Lenox

Date collected: September 2016

Document analysis Guide: Teachers document (lesson plan)

Lesson plans are historical documents and resources that provides reflective evidence of teaching philosophy and anticipated activities in the classroom (Jensen, 2001).

Significance of this document: To know how teachers originally planned and prepared for their lessons.

Criteria	**Comments**
Teacher's description of how the lesson fits into a larger curricular unit	✓ Teacher did not describe how the lesson fits into a larger unit of the curriculum. ✓ Importance of the lesson to learners was not clearly stated in the lesson plan.
Activities in teacher planning that assessed or stated learners' prior knowledge	✓ Teacher did not describe what learners should already know before attending the lesson. ✓ No explanation on how learners' previous knowledge for this lesson was assessed in previous lesson.
Outline of inquiry methods to be used while teaching the lesson	✓ No indication of teaching methodology to be used in the teacher's lesson plan.
Outline of teacher's expectation of what learners should know and be able to do at the end of lesson	✓ Lesson plan did not indicate any form of goals and objectives of the lesson to be covered.
Instructional materials teacher's used in the class while teaching the lesson	✓ Teacher did not outline the instructional materials used in his lesson plan ✓ Teacher's lesson plan did not indicate any practical activity or demonstration for learners
Content/procedure standard	✓ Lesson plan is not written in details according to standard. ✓ Points to be discussed were only summarized on the teacher's planned note.
Teacher's feedback to learners	✓ No evidence of teacher's feedback to learners in the initial lesson plan.
Teacher's wrap up/ conclusion	✓ No indication of how teacher planned to conclude his lesson.
Planned learners assessment	✓ No indication of learners' assessment or planned learners class activities in the teacher's initial lesson plan
Notes for teachers to reflect on the lesson taught.	✓ Lesson preparation reflected only key points that learners are expected to know. ✓ No reflection of possible learners' difficulties to be addressed in the teacher's original lesson plan.

Teacher's Pseudonym: Mbali

Date collected: September 2016

Document analysis Guide: Teachers document (lesson plan)

Significance of this document: To know how teachers originally plan and prepare for their lessons.

Criteria	**Comments**
Teacher's description of how the lesson fits into a larger curricular unit	✓ Teacher did not describe how the lesson fits into a larger unit of the curriculum. ✓ Importance of the lesson to learners was not stated in the lesson plan.
Activities in teacher planning that assessed or stated learners' prior knowledge	✓ Teacher did not describe what learners should already know before attending the lesson. ✓ No explanation on how learners' previous knowledge for this lesson was assessed in previous lesson.
Outline of inquiry methods to be used while teaching the lesson	✓ No indication of teaching methodology to be used in the teacher's lesson plan.
Outline of teacher's expectation of what learners should know and be able to do at the end of lesson	✓ Lesson plan did not indicate any form of goals and objectives of the lesson to be covered.
Instructional materials teacher's used in the class while teaching the lesson	✓ Resources and materials required for teaching the lesson was not specifically stated in the teacher's plan. ✓ Lesson Content indicated some of the required resources learners should know ✓ Teacher explained a practical activity on electromagnetic induction for learners as observed in her lesson plan
Content/procedure standard	✓ Lesson plan is adequately linked to content standard. ✓ Notes to be given to learners were clearly explained in the teacher's planned note. ✓ Practical demonstration of the lesson was well explained.
Teacher's feedback to learners	✓ No teacher's feedback indicated in the initial lesson plan.
Teacher's wrap up/ conclusion	✓ Teacher concluded by summarizing the main points of the lesson.
Planned learners' assessment	✓ Limited use of assessment strategies to measure learners' knowledge and understanding of the lesson.
Notes for teachers to reflect on the lesson taught.	✓ Teacher did not reflect on possible learners' difficulties to be addressed in her initial lesson plan. ✓ No reflection on learners' learning and teacher's improvement plan.

Appendix 18: Interview transcript for Lesson Study pair B

Appendix 18A: Alex's Interview transcript

Pre-Interview conducted on the 24/04/2017; Time 14:10 – 15:25

Researcher's note	Interview questions	Codes	Sub themes	Themes
Alex's qualification certifies him to be a teacher within the South African context.	**Researcher:** what is your highest qualification as a teacher? **Interviewee:** If I may say, I have a Bachelor of Education for FET Phase in Natural Sciences	Teacher certification	Content Knowledge	Teacher's professional competence
The teacher has a foundational knowledge of the subject he is teaching based on the courses offered at the university level.	**Researcher:** What do you mean by FET phase in Natural Science? **Interviewee:** Yea, that's combination of Chemistry, Physics and Biology but I choose to do Physics, Chemistry and Mathematics as separate courses at the university because I am not a biology person.	Teacher's certification Teacher's foundational knowledge	Content Knowledge	Teacher's professional competence
Alex is conversant with the grade 10 syllabus due to his years of teaching experience.	**Researcher:** Ok, so for how long have you been teaching Physical sciences? **Interviewee:** Currently this is my fifth year.	Teacher's teaching experience	Content Knowledge Pedagogical knowledge	Teacher's professional competence
He became a teacher out of his passion for educating younger people.	**Researcher:** Teaching for five years. So why did you become a teacher? **Interviewee:** I never even sat down to think of this. But I think this was a decision I made from my matric days. I enjoyed science as a subject while I was in school and I thought it would be a nice thing if I also teach what I know to young ones.	Teacher's passion for the profession Teacher's character Teacher's attitude Interest in teaching science	Teacher's belief	Teacher's professional competence
It is evident that his years of experience would have helped him to accumulate	**Researcher:** So, you basically have five years' teaching experience?		Content Knowledge	

some skills needed in teaching the subject.	**Interviewee:** Yes, I have been teaching grade 10 for five years since I started my teaching career, but along the line I have also taught grade 11 and 12 for about say two to three years.	Teacher's teaching experience across FET phase		Teacher's professional competence
Alex believes that learners struggle with concepts related to circuit connection.	**Researcher:** okay, In your five years' experience as a Physical Science teacher what can you say about learners difficulties in electricity and magnetism? **Interviewee:** Hmmm, for electricity and magnetism I will say learners' difficulties and misconceptions is basically in parallel and series circuit. Learners find it difficult to understand when current splits and divides in a circuit. Also, they don't understand the concept of resistance in a parallel circuit.	Teacher's perception about learners' difficulties; Teacher's own knowledge Teacher's character Learners have problem in electric circuits	Teacher's Subject knowledge Teacher's belief Knowledge of Learners	Teacher's professional competence
Teacher was confident that learners' difficulties in electricity cuts across all grade at the FET phase.	**Researcher:** Okay, Is this problem you have mentioned pertaining to only grade 10? **Interviewee:** No this is a problem with mostly grade 10 and 11 learners because at grade 12 they deal with internal resistance which I think is quite simple and easy to understand.	Teacher's confidence of learners' problem Teacher's perception about learners difficulties	Teacher's attitude	Teacher's professional competence
Teacher's perception of learners' difficulties in electricity and magnetism	**Researcher:** Okay, since you have experience with grade 11 and 12, what are the difficult concepts in electricity and magnetism at this grade too?	Teacher's own knowledge	Content Knowledge	

varies across all grade levels. He believes that grade 10 learners struggle with electric circuit while grade 11 learners struggle with electric circuits and electromagnetism. And grade 12 learners struggle with electric circuits and electrodynamics.	**Interviewee:** In grade 11, the major problem is electromagnetism. You know there is no detail explanation on how electricity and magnetism relates so u just teach the relationship based on textbooks and learners still can't comprehend the relationship between the two. Understanding Magnetic flux and magnetic field strength is very much confusing to learners because its closely related. Learners also struggle with this concept of induced magnetic field, left hand rule and right hand rule. Then for grade 12 I will say some times learners struggle with the concept of generators.	Learners don't understand concepts in electromagnetism	Teacher's Knowledge of learners	Teacher's professional competence
Teacher indicated that learners' difficulties slows down the pace at which he teaches the subject.	**Researcher:** Does these learners difficulties and misconceptions affect your classroom teaching or practice in any way? **Interviewee:** yes it does because it takes my time, I have to explain over and over and you find out sometimes I waste most of lesson period on motivation and explanation; not teaching the planned lesson. Another thing is that when you give them homework most of them don't do it and they tell you it's because the homework is difficult so you end up doing the homework for them and takes like half of your teaching period because you have to explain to make sure they understand the home work. So you see this is a problem….their attitude to homework.	Teacher's confidence Teacher's belief Re explaining , Motivating learners Learners attitude to homework	Teacher's attitude Pedagogical skills Knowledge of learners	Impact on practice
Teacher has tried using several teaching	**Researcher:** How have you addressed the difficulties that learners have in these topics you just identified.			

strategies to address learners' difficulties in the mentioned knowledge area.	**Interviewee:** To be honest I do a lot of explanations, examples, use simulations and analogies to teach some times.	Explanation, analogies, simulations	Pedagogical skills	Teacher's professional competence
He is confident that the strategies employed in addressing learners' difficulties in this topic is effective.	**Researcher:** Has your method been effective? **Interviewee:** Well, I feel it's quite effective because I try to use a lot of picture and internet materials too to enhance their understanding.	Teacher's confidence that method is effective	Teacher's belief	Teacher's professional competence
		Use of picture, internet	Pedagogical skills	
Teacher is struggling with some grade 11 and 12 concepts but he believes he has no problem with grade 10 topics since they are basic.	**Researcher:** As a teacher, is there any concept or knowledge area in electricity and magnetism that sometimes appear challenging to you? **Interviewee:** Electricity is a topic that I quite enjoy, eeem so the only thing I will say I struggle with is electrodynamics at grade 12 and electromagnetism at grade 11. This left-hand rule, right hand rule, direction of current, direction of magnetic field is still a bit challenging to me.	Teacher's belief	Teacher's attitude	Teacher's professional competence
		Teacher's own knowledge Teacher's difficulty	Teacher's content knowledge	
Teacher does not really involve in collaborative discussion with other teachers within or outside his school.	**Researcher:** Do you discuss any of these challenging topics with your colleagues inside or outside the school? **Interviewee:** I don't discuss it much with anybody because am not open to asking so I just try and look for more resources to read and prepare myself before going to class. However, I have a colleague from another school who we sometimes discuss things like this together in terms of past exam questions and all that but unfortunately we don't go in-depth as regarding learners' difficulties.	Teacher's belief	Teacher's attitude	Teacher's collaboration

Teacher expects learners to ask questions whenever they don't understand a topic or concept.	**Researcher:** Okay, when teaching in the class what do you look out as evidence of student learning? **Interviewee:** I try to make an open communication in my class when discussing or teaching any topic. So, I expect them to ask questions for clarification on what they don't understand. I also give them short test between 5 and 10 minutes, they switch for marking as I do correction and sometimes I go through the short test just to see if they followed the standard of marking.	Open communication	General pedagogical knowledge	Teacher's professional competence
		Teacher's expectation from learners	Teacher's attitude General pedagogical knowledge	
		Assessment test	General pedagogical knowledge	
Teacher takes time to reflect on his previous class teaching before going to his next class.	**Researcher:** since you are aware of these learners' problems; how often do you reflect on them? **Interviewee:** I think am fortunate to handle two classes, so when I teach a class and see that there is a problem, I try to improve better when preparing for the other class. So, I try to look at how my lesson presentation went immediately after teaching my first class.	look at how my lesson went;	Reflection	Impact on practice Teacher's professional competence
Teacher does more of practical demonstration than one on one practical activity with learners.	**Researcher:** If I may ask, how often do you expose your learners to practical activities in Physics? **Interviewee:** Basically, I follow the CAPS document and since the time required to teach scheduled topics in the syllabus is not sufficient learners only do practical on electric circuit as prescribed but I make sure I do some demonstrations on concepts like magnetic field and I also use pictures on power point to show them some basic instruments.	Teacher's use of Practical demonstration	Pedagogical practice	Teacher's professional competence
		Insufficient time to cover syllabus	Time factor	Contextual factor
Teacher does not attend professional development	**Researcher:** Alright, so as Physical sciences teacher, how often do you attend professional development trainings or workshops?		Teacher's professional	

program as often as he should in the last 3 years.	**Interviewee:** In my first two years, I attended quite a lot of workshop but after then I will say not so much probably once a year.	Teacher's participation in professional development programs	development needs	Teacher's professional competence Impact on practice
He believes that the school's support for professional development program is not enough.	**Researcher:** Once a year, but why? **Interviewee:** I think it's an issue with the school budget. If there is no plan for it from the school, you cannot just go.	Problem with school budget	Support from the school	Contextual factors
Teacher believes that professional development programs organised by the department focuses more on what he already knows with respect to content knowledge.	**Researcher:** But being a public school, I think the department should also be responsible for some workshops. **Interviewee:** Yes, but you know the department give these workshops to facilitator who just come to tell you the same thing over and over. I will say they just repeat what you know and don't really add to your knowledge. So, the school sometimes allow us to attend practical ones organised outside by some universities and professional bodies but there need to be a budget for that.	Organised workshops by the department Support from the school Repetition of information by facilitators from the department	Support from respective education authorities Need to improve teacher's workshop	Teacher's collaboration Contextual factors
Most professional development programs that the teacher has attended were focused more on Chemistry and nothin on Physics since he started his teaching career.	**Researcher:** Okay, so the professional programmes you have attended are they on Physics or Chemistry? **Interviewee:** To be candid, I have never attended any professional training focused on Physics. The ones I have attended were on chemical reactions, common Chemistry experiments that can be performed at home then mostly on grade 12 Chemistry concepts like esters.	No workshop exposing teacher to first hand methodologies in Physics	Need to improve teacher's workshop on Physics methodologies.	Teacher's collaboration Teacher's professional competence

Teacher believes that facilitators handling professional development programs only deal with general knowledge of the subject and they don't go into details of the specialized discipline.	**Researcher:** Why is there no training focused on Physics? **Interviewee:** You know most of these workshops are not presented by the department but external providers so basically they just give a general overview of what Physical sciences is and they don't go into details of the various aspect of the subject.	Teacher's belief Teacher's perception Outcome from workshops	Teacher's attitude	Contextual Factors
Teacher believes that their suggestions does not count since they don't get feedback of their complaints to the necessary office involved in the training of Physical sciences educators.	**Researcher:** As a Physical sciences teacher, what are you doing to make sure you attend the necessary professional development you need? **Interviewee:** we had several communications with the department but we are yet to see any feedback. Also, I remember we were given a form to fill around last year on the professional trainings we needed but I can't remember seeing any plan for Physical sciences teacher and I don't know why?	Communicating with the department without feedback No provision for training Physical sciences teachers	Problem with collaboration	Teacher's collaboration

Post-Interview for Alex, conducted on the 01/06/2017; 14:20-15:00

Researcher's note	**Interview questions**	**Codes**	**Sub themes**	**Themes**
Alex response reveals that he enjoyed participating in the study.	**Researcher:** How would you describe Lesson Study? **Interviewee:** Thinking of it from the very day you described what it's all about, I viewed it as an interesting model.	Interesting model	Description of Lesson Study Sensational Feelings	Lesson Study experience

The first -hand Information provided to Alex about the study captivated his interest in participating in the research and his mind was prepared to know how Lesson Study works.	**Researcher:** Wahoo, interesting model! So, what is interesting about it? **Interviewee:** when you talked about it at my first meeting with you and going through the pamphlet you gave to me, what came to my mind during the meeting was interesting. I felt the way you explained the whole idea was interesting to me since it focused on how to teach so I took time to check for information about it online then I realized that this is something that needs commitment. So, it's interesting because I learnt something new and that from a teacher outside my school and a university student**.** It's interesting because the whole phases involved is a little complicated and time consuming so I see it as something that requires commitment and hard work like every teaching activity does and like I already read from an internet source.	Teacher learning Collaboration	Benefits of Lesson Study	Lesson Study experience
		Requires Commitment Complicated process Time consuming Requires hard work	Challenges of Lesson Study	
Alex's response reveals that his description of Lesson Study as interesting was based on his ability to plan lessons together with another teacher focusing on their learners' expectation from the lesson.	**Researcher:** okay, so what can you say is the most interesting aspect of your experience and why? **Interviewee:** All the phases are interesting but I think taking time to discuss teaching strategies that are appropriate for specific lesson together and critically considering how a lesson should be planned towards your expected learners' outcome makes it quite interesting.	Teachers perception about Lesson Study	Benefits of Lesson Study (teacher's belief)	Lesson Study experience
		Teaching strategies Lesson organisation	Benefits of Lesson Study(Pedagogical practice involved)	
		Discussing together	Benefits of Lesson Study (teacher collaboration)	
Alex indicated few contextual factors that did not give him the	**Researcher:** So, is there any phase of this interesting model that is challenging to you? **Interviewee:** Being committed is a challenge because as teachers we have many responsibilities so time is a	Commitment Time factor	Challenges of Lesson Study	Lesson Study experience

opportunity to effectively utilize all the phases involved in the lesson as expected.	challenging factor. Aside that I think the whole process is what is needed to help teachers improve on what they don't know and eeem…..writing the lesson plan especially when I needed to write my expectation from learners was quite challenging because at first I did not know what to expect from the learners. These learners are unpredictable.	Teacher's job responsibilities Lesson plan writing	Contextual factors	
Alex beliefs that the success of Lesson Study depends on the persistence in terms of interest and commitment of all stakeholders involved	**Researcher:** Okay looking at your comments so far do you think Lesson Study can work as a teaching methodology among teachers? **Interviewee:** Can it work? I think it should depend on teacher's interest and commitment but first an idea like this should be made known and facilitated by the department. Personally, I think I will still love to do something like this probably with teachers in my school if the principal approves of it and if the other teachers in science field are willing to because teachers are not willing for anything these days due to the many tasks involved in this profession.	Teacher's interest Teacher's commitment	Teacher attitude	Contextual factors
		Support from the department Support from school principal	Support from stake holders	
		Many tasks involved in the profession.	Job responsibilities	
Alex believes that the different phases involved in Lesson Study is significant to teacher's professional development.	**Researcher:** Smiling, okay. So, which of these Lesson Study processes is more valuable or more important to you and why? **Interviewee:** The whole process is a valuable one and significantly important. One phase serves as a building block for the other so I don't think separating any will be effective. You know I have attended few collaboration activities but time has not permitted me to practice what I have learnt. But this one gives you the opportunity to immediately practice what you learn or what you have	Teacher's belief First hand practice Working with others	Benefits of Lesson Study (collaboration)	Lesson Study experience Teacher collaboration

	done with others to see how effective it works for you in your capacity either in teaching or planning or something similar. So, that's it.			
Alex believes that collaborating with another made him realize the importance of relating classroom lesson to real life situations.	**Researcher:** Reflecting on this Lesson Study process, how has the role of collaborating with a teacher from another school affected your professional knowledge and practice? **Interviewee:** In this regard, I always believe that learners have an idea of how science relates to them in their environment so I never really took my time to relate my lesson to things in the learners' immediate environment. So, I think I realized this when you asked me a question about the introducing my lessons using life challenges. So, this is one part I realized I need to improve on and that is because you pointed it out that it was not observed in any of my lessons. So yea, relating with you made me realize the significance of letting learners know that for instance circuit is everywhere in our phones, television, sound system and all that.	Change in teacher's belief about learners' application knowledge Improve teacher's lesson introduction approach	Teacher learning	Teacher collaboration
Alex was confident that the presence of another teacher in his class increased his learners' level of concentration.	**Researcher:** clarified, thank you sir. So, how significantly has your experience in this study affected your professional practice? **Interviewee:** I don't know if this is part of the program but I think your presence in the class made the learners attentive and respond well to my question. So I think having an outsider in the class could sometimes create a good environment for learners to want to show that they know what they are doing but believe me not all learners would love that anyway. Smiling, on the other hand during your discussion on what you observed in the class, I	Increase in learners' concentration Using lesson observation to identify how learners learn.	Learners' learning Pedagogical practice	Impact on practice

	realized that having class observations like this could sometimes help teachers to identify the gaps between learners understanding of a lesson and teacher's method of teaching the lesson. You know I can be teaching a lesson but the way learners understand the lesson could be wrong or right so having an outsider observe how learners learn could sometimes help teachers to identify learners' reaction during the teaching because I believe as a teacher I can only see what I want to see and not the whole thing happening in my class.			
The teacher was very confident that time would not allow him to practice Lesson Study effectively as a teacher due to job responsibilities.	**Researcher:** So, are there any factors that might possibly affect your continuous use or practice of Lesson Study as a teacher? **Interviewee:** Practically the only constraining factor I see here is time. Teachers are always busy and we have a lot of things to cover within a limited amount of time. So, that alone is a problem. Although I think there are other factors too which could probably surface along the line.	Time Too much responsibility	Resources Work load	Contextual factors
Teacher believes that Lesson Study can be effective if all stakeholders are committed into making it work.	**Researcher:** So, what are the likely factors that could surface along the line? **Interviewee:** You see for a program like this to be accepted, the interest of the teacher is very important. On the other hand, is the issue of getting support from the school which I explained when we spoke the other time. For instance, I have been trying to find out from the school if I could attend a training but the school has no budget for that since the department is not involved. Eeeem…. yea I think these are my views for now.	Teacher's interest Support from school	Teacher related factor School leadership	Contextual factors

Appendix 18B: Martha's Interview transcript

Pre-Interview conducted on the 21/04/2017; Time 14:10 – 14:55

Researcher's note	Interview questions	Codes	Sub themes	Themes
This is an indication that the teacher's first degree does not qualify her to be a teacher.	**Researcher:** what is your highest qualification as a teacher? **Interviewee:** I have a BSc in Human Genetics	Teacher's certification	Content Knowledge	Teacher's professional competence
Teacher's interest in the profession motivated her to enrol for further studies that qualifies her to be a teacher.	**Researcher:** Human Genetics, so how come you are a teacher? **Interviewee:** Actually, I also did a PGCE program and both degrees were from university of Pretoria	Teacher's certification	Content Knowledge	Teacher's professional competence
It appears that Martha has a foundational knowledge of the subject at the university level.	**Researcher:** Okay, so what's relation between human genetics and teaching Physical sciences? **Interviewee:** I did both Chemistry and Physics courses at the university so that gives me the opportunity to know more about the subject.	Subject discipline at University level	Content Knowledge	Teacher's professional competence
Apart from Martha's interest in the profession, it clearly indicated that she also chose the profession due to need for financial stability and family legacy.	**Researcher:** Human Genetics, so why did you come into teaching and not practice in your field? **Interviewee:** What should I say, I think it's the money…...smiling. I think I have loved teaching from a very young age back when I use to help my twin sister study, do her school work and all that. So, I fell in love with teaching and I am enjoying it. Eeeem…. you know my mum is also a teacher and she now works for the education department district office. So, it's like mum, grand mum and grand pa were all teachers; and it's becoming more of a family thing and I enjoy what I do every day. They drive me mad; don't	Steady Income	Financial Support	Contextual factors
		Motivation based on family career practice	Family Support	
		Passion for the profession; Teacher's interest in teaching	Teacher's belief	Teacher's professional competence

	get me wrong. They are naughty sometimes and they have this bad attitude towards science but I still enjoy what I do.	Learners negative attitude towards science	Knowledge of learners	
Teacher sounds comfortable with her work environment due to her long years of service in the school.	**Researcher:** Wahoo…that's awesome. So, for how many years have you been teaching? **Interviewee:** I have been teaching for seven years now. I actually started my teaching career here in this school?	Teaching experience	Content Knowledge	Teacher's professional competence
Martha sounds happy with her job in this present school but suggest possibility of moving to a new work environment for personal development.	**Researcher:** Great, spending seven years in a single school, how has it been? **Interviewee:** Well I have been enjoying it but you know when you spend like 25 years or more in a single school it gradually becomes boring though I might try looking for another opportunity in another school again so I can experience new challenges because teaching requires you to always be on the run.	Teacher's perception Teacher's love for her Current Job Growth opportunities	Teacher's belief	Contextual factor
Her response to the years of teaching experience reveals that she is familiar with the required grade 10 lesson content.	**Researcher:** That's a good opinion. So, in your seven years what grade level have you been teaching? **Interviewee:** I have been teaching Physical sciences in grade 10 for 7 year, Grade 11 for 2 years and Grade 12 for a year.	Teaching experience	Content Knowledge	Teacher's professional competence
Martha's has several professional responsibilities across different subjects and grade levels.	**Researcher:** Apart from Physical sciences, is there any other subject you teach? **Interviewee:** Presently I am teaching 2 classes of grade 10 and 1 class of grade 12 Physical sciences and I am also teaching grade 10 and 12 technical science.	Teaching responsibilities	Work load	Contextual factors
I believe that Martha's class size is minimal	**Researcher:** Okay, so how many learners do you have in a class?	Class size	School factor	

enough to encourage individual attention for learners struggling with challenging lesson contents	**Interviewee:** The number of learners in my class varies but they range say between 35 and 40 learners per class.			Contextual factor
Martha believes that learners' problems in electricity and magnetism is a Mathematical one which is centred on electric circuit across grade 10, 11 and 12.	**Researcher:** That's quite minimal. In your seven years' experience as Physical sciences teacher what can you say about learners' difficulties in electricity and magnetism? **Interviewee:** Taking a critical look at grade 10 and 11, Basically I will say it's the maths especially when you get to series resistor, parallel resistor and combine effect of both series and parallel circuit connection. They don't know how to do conversion. At grade 12 I can't say much because this is my first time taking grade 12 but from the past exams I believe that grade 12 learners also struggle with electric circuits.	Problem with series, parallel and circuit combination; Maths problem;	Knowledge of learners difficulties	Teacher's professional competence
Apart from electric circuit Martha was very confident that learners face problem in electricity and magnetism when teaching concepts related to electromagnetism at grade 11.	**Researcher:** Okay so is the difficulty only in electricity? **Interviewee:** Well for grade 10 I will say yes although some of them still struggle with details on how to draw magnetic fields but the percentage is very small so I don't think that is a problem. For grade 11 there is this big problem when it comes to magnetic flux. It is a difficult concept for the learners.	Difficulties in drawing magnetic field lines; Problem understanding Magnetic flux	Knowledge of learners difficulties	Teacher's professional competence
It seems Martha struggles with her teaching when dealing with problem solving concepts of	**Researcher:** Looking at these learners' difficulties how does it affect your classroom practice when teaching? **Interviewee:** hhmm definitely a lot. The biggest problem for me here is like teaching two subjects in a class before I can teach them any calculation aspect of Physical sciences	Teaching double subject; Consumes more teaching time;	Lesson delivery	Impact on practice

Physical sciences and this also affects her methodology.	I have to first teach them the basic maths needed before doing the science aspect of my subject so for me it takes my time. And this is the problem with most of my learners since they don't understand or know simple maths. So, each time I do these maths and science teaching together in my class I tend to get lost somewhere in the middle of the whole process…smiling.	Teacher's confusion Learners don't understand simple maths	 Knowledge of learners difficulties	
Martha seems so confident of her learners' problem in Mathematics but she is not doing much to address this problem than to encourage learners to keep practicing more questions. But she developed other ways of capturing learners' interest about some concepts in electricity and magnetism.	**Researcher:** Okay so what method have you been using to address your learners problem in electricity and magnetism? **Interviewee:** Maths is very much relevant in understanding Physics and this is a big problem for my learners. However, for example in grade 10 magnetism I try as much as possible to do practical even if it's just a demonstration. For the electricity, what I have done is that I downloaded simulations and until last year we had a computer centre unfortunately our computer centre is closed this year but am going to try and get something for my class this year. But the simulations have helped quite a lot because they can see what happens with the voltage and current when resistance are either connected in series or in parallel that type of thing. Eeem but otherwise practice make perfect. Practice practice practice.	Practical demonstration Downloaded simulations Encourage learners to practice	Pedagogical knowledge Practical skills	Teachers professional competence

Though Martha indicated that her school is fortunate to have a laboratory unfortunately the laboratory is sufficiently equipped with apparatus that can be used by individual learners.	**Researcher:** Okay now you just talked about practical demonstration. Do you have laboratory equipment to facilitate learners' practical activities in electricity and magnetism? **Interviewee:** Let me say we are very fortunate. The whole back of my class is lab space. So, I consider that I can let them do experiments in groups and not individually because we don't have enough to go around for all the learners and besides that most of our apparatus or equipment as called are very old and some are not functioning properly. For example, our ammeters are not working properly and that's why I use the phet simulations I talked about earlier. I believe it's better using the simulations than using a faulty equipment which could end up confusing the learners more than they already are. I also try to download more videos from the internet which has basically helped me quite a lot whenever I am teaching the concept of magnetic flux.	Insufficient resource equipment; Old resource materials ; Faulty laboratory apparatus Use of simulations Download videos Internet resources	Resource needs Pedagogical knowledge	Contextual factors Teachers professional competence
Martha indicated that she checks for her learners understanding while the lesson is still going on and she is confident on the effectiveness of her new pedagogical approach.	**Researcher:** Okay so when teaching these learners how do you know that a learner understands your teaching or has successfully overcome the difficult concept in this knowledge area? **Interviewee:** eeem it's very very difficult. Eeem In my class I work on question and answer basis. So generally, what I do is I pick learners randomly to answer a question especially learners I notice are not paying attention. I have been doing this from January and at this stage I feel that the concentration level in my class has increased because they get scared that I might pick on them to answer questions and they don't want to feel bad in front of their	pick learners randomly for question and answer during teaching process	Pedagogical knowledge	Teachers professional competence

	other class mates. So, I think this has been effective in the aspect of learners' concentration.			
Martha did not specify any concept that appears difficult to her but indicated that she is struggling with the grade 12 Physical Science content because it's her first time teaching learners at that grade level.	**Researcher:** Okay, as a teacher is there any concept in electricity and magnetism that appears confusing or difficult to you? **Interviewee:** Yes, I did definitely; especially with the grade 12 syllabus may be because this is the first time teaching it so it's new to me. But with the grade 10 I don't have a problem since that's what I have been teaching over the years.	Difficulty on grade 12content Teacher's belief Teacher's confidence of her teaching challenges	Teacher's content knowledge Teacher's attitude	Teachers professional competence
Martha believes that when teachers struggle understanding some concepts it helps them to identify possible learners' difficulties.	**Researcher:** How do you overcome these difficulties you experience as a teacher? **Interviewee:** Google………smiling. This is any one's best friend in life. Videos, animations and all that. Apparently, it helps to know that educators also struggle with some contents because then you know what the learners' problem could be.	Internet resources 21st century learning approach	Pedagogical skills	Teachers professional competence
It seems that Martha believes so much on the use of internet resources and I think this affects her level of collaboration with	**Researcher:** So, you said google but don't you discuss this difficult concepts with other teachers in your school or outside your school? **Interviewee:** Yes, I do. For grade 12 I sometimes discuss with my HOD and grade 11 I do have short discussions with the other teacher but for grade 10 I have no one to	Short discussions with HOD and colleague; No meeting with teachers outside the school		Collaboration

teachers within and outside her school.	discuss that with. So, my HOD helps a lot with the grade 12 work. I quickly run to her to explain one or two things and that is it. But we have not really had that time to sit down for an in-depth discussions that last long if you know what am trying to say. Everybody is busy with their own thing and our teaching periods are different so that free period where we all gather together has not really surfaced based on the time table. From outside school, let's not delve into that.	No time to sit down for in-depth discussions Difference in teaching periods;	Time factor	Contextual factors
Martha believes that assessment evaluation and learners ability to ask questions helps her see how well they understand a lesson or not and that serves as the evidence that they are learning.	**Researcher:** Okay we already talked about the learners' difficulties but as a teacher what do you look out for as evidence of student learning when teaching**?** **Interviewee:** There are certain things that help me gather evidence that they are learning. Like I said class test which helps a lot because then I can identify which learner understand and which does not. I also give them homework and expect them to ask question on every single aspect of the homework which they don't understand. After which I try to give one on one help to them when they call my attention.	Assessment test Home work Teacher's expectation from learners Individual attention to learners	General pedagogy	Teachers professional competence
Martha had earlier indicated that learners have a negative attitude towards home work which she is trying to change by using strategies outlined in the school's code of conduct.	**Researcher:** For the learners that don't do their homework, is there any corrective measures in place for that? **Interviewee:** Yes, we do have a demerit measure in the school where we contact their parents and put them in detention on Friday afternoons. So, that's basically what we do in this school.	School's demerit measures Consultation with parents Putting learners on detention	Teacher's Disciplinary capabilities	Impact on practice

It seems Martha always considers her learners background as a contributing factor to their negative attitude towards home work.	**Researcher:** Has these measures been effective? **Interviewee:** Some of them I will say yes. But I think it's important to understand the learners' background. It's not always their fault for not doing their homework so I try as much as possible not to give too much homework. For instance, learners, will be writing test this week so they won't be given homework. So, what I try to do is keep the parents involved and follow up on the kid.	Teacher's understanding of learners background Teachers flexibility on home work	Knowledge of learners	Teachers professional competence
		Communication with parent	General pedagogy	
It is evident that Martha provides a general feedback on learners' activities by doing correction on the board but does not take time to make helpful marking comment on her learners' book.	**Researcher:** When you said follow up, does that mean you mark their books? **Interviewee:** Eeem basically I have a stamp that I use on every child's book. Sometimes when I give them class activities or homework and do correction I use the stamp to indicate in their book that the homework or activity was done and seen by me.	Endorsing learners work using a stamp Provide correction on learners work	Teacher's attitude	Teachers professional competence
Martha has repeatedly emphasized on how she collaborates with her HOD for help on better ways of teaching difficult lessons but she rarely takes time to personally reflect on what happens during her teaching due to her busy schedules.	**Researcher:** As a teacher how often do you reflect on your learners' difficulties and their performances in class. **Interviewee:** Not as often as I should ……smiling…to be completely honest with you. Eeem I think time is a problem. We offer extra classes in the afternoon so most afternoons I am busy with extra classes or revision classes so I don't have that free time to sit down and look at everything that happened in my class. You know I believe every teacher gets that one lesson where they feel things are just not right**; a** feeling that learners don't understand your lesson at all. So whenever I have such feelings about	Time	Problem affecting teacher's reflective practice	Contextual factor
		Teacher's intuition about learners understanding	Reflection	Teacher's professional competence; Impact on practice

	my lesson I go back and look at it that what is they don't understand; how can I explain it. Then I go to my HOD and ask how she would explain the same lesson or concept to learners. So, I think that's how I do my reflection	Discussion with HOD for better clarification	Collaboration	Teacher's collaboration
It seems that Martha's uses result gathered from her assessment evaluation to reflect on learners learning and understanding of her lesson.	**Researcher:** Okay so what is your reflection based on? **Interviewee:** My reflections are usually based on like I said questions and answers in class; and the class test. So, it's definitely the class test and cycle test so it makes me go back to see how the learners do things.	Assessment of how learners learn Question and answer Assessment test	Methods of Reflection General pedagogical knowledge	Impact on practice
I believe that Martha rarely attends professional development trainings or workshop due to communication breakdown between teachers and school administrators even though she earnestly desires to attend specific workshops if available.	**Researcher:** How often do you attend professional development programs? **Interviewee:** Not as often as I should. Eeem we don't have a lot in our cluster or maybe I say we hear of them very late because the means of communication from the district office to this school is not effective. I will hear there is a workshop for this afternoon and I already have a plan for the afternoon so I end up not going. But as often as possible I try my possible best to attend the meetings or workshop I am aware of. Eeem I will like to attend anyone pertaining to grade 12 now if I am opportune to. Usually these workshops are about teachers training teachers.	Teacher's perception about professional development. Communication barrier between district officials school authorities. Teacher's attitude to professional workshops. Teacher's desire to attend specific workshops.	Professional development needs	Impact on practice

Martha's Post-Interview conducted on the 05/06/2017; 14:05- 14:55

Researcher's note	Interview questions	Codes	Sub themes	Themes
It seems Martha has attended few workshops that focused of lesson content and not teaching strategies; so her description of Lesson Study was focused on teachers collaborating to improve their pedagogical practice.	**Researcher:** How would you describe Lesson Study? **Interviewee:** I feel this is a kind of workshop that could help teachers work together to find better ways of teaching a concept instead of this practice where a senior teacher reteaches the content of a lesson to the junior teacher. I like the fact that it is focused on how learners learn and not on content…. You see I believe if this kind of workshop is well planned and not giving us teachers information at the last minute when the workshop is to take place it can yield a good result.	Teachers work together Find better ways of teaching Focus on learners learning	Description of Lesson Study Improved pedagogy	Lesson Study experience Teacher collaboration
Martha indicated during the first Lesson Study meeting that she does not write a lesson plan but participating in Lesson Study has increased her knowledge of elements to be considered when writing a lesson plan.	**Researcher:** What has been your experience while participating in Lesson Study? **Interviewee:** The lesson design; writing a lesson plan using the template you gave was an experience because we don't write lesson plan; my HOD provides the already written lesson plan from the department and I just teach. So, taking my time to write a lesson plan based on the template you gave was quite interesting and challenging if I would say.	Teacher's belief about writing lesson plan Knowledge of lesson plan writing	Challenges of Lesson Study Teacher learning	Lesson Study experience
It seems Martha believes that writing lesson plan intellectually challenging.	**Researcher:** Why did you say writing a lesson plan is challenging? **Interviewee:** I had to think of what to write, make sure it is what the CAPS document requires, ensured that it is relevant to my lesson and what we discussed in the meeting. So it got me thinking each time I am writing it but thank goodness it's for two lessons if not…..smiling.	Requires thinking Teacher's belief about writing lesson plan	Challenges of Lesson Study	Lesson Study experience

I feel that Martha's participation in this study stimulated something in her that reminded her of how to integrate her scientific knowledge to her learners	**Researcher:** What aspect of these Lesson Study process is more interesting to you? **Interviewee**: I said earlier that the lesson plan writing was the most interesting part of your research work to me. However, let me say I realized that the focus of all what we were doing was looking for ways on how to prepare these learners for the world out there because as a teacher I believe that science is everywhere. I find it interesting because for every lesson plan I wrote I kept having it at the back of mind that learners must be able to do things on their own and also indirectly work with one another.	Lesson plan writing Focus on improving learners learning Ability to recall what works best for learners Teaching Pedagogy	Benefits of Lesson Study (teacher learning)	Lesson Study experience
		Teacher's perception about science	Teacher's belief	
It seems Martha would have loved to observe Alex's class during the study but she had a lot of challenges based on her busy activities as a result of her teaching work load, sub admin responsibilities and extra lesson periods in the school.	**Researcher:** What aspect of these Lesson Study process is more challenging to you? **Interviewee:** Remember you were explaining something on both of us observing each other's class. It's something I would have loved to do but it's quite challenging because I believe we teachers don't have the luxury of time on our side. The term is short and imagine the volume of content we are to teach including other subjects we handle. But I must recommend how you tried scheduling the afternoon meetings even though it was not convenient and later did not go well as you initially discussed it. So, you can see that time is a problem.	Classroom observation Limited time frame for school term Work load Don't have essential time for teaching	Challenges of Lesson Study	Lesson Study experience Contextual factor
I believe Martha is finding it difficult to participate in professional trainings due to time constraint but she	**Researcher:** Hmmm, you said time is not a luxury on your side, so what do you think can be done? **Interviewee:** Most of the times we give suggestions but at the end it's nothing. In my honest opinion bringing programs like this to schools should be handled by the	Departmental support Teacher's interest	Teacher's perception	Impact on practice

believes that teachers' participation in professional workshops can be effective if the school time table involves specific dates for such development.	department. And possible if they can fix a particular time in a week for things like this either within schools or across schools. But one thing I must tell you is that I believe many teachers will just not be interested because we sometimes see everything like additional burden on us.	Time organization for professional development Improving teachers professional development		
Martha's response reveals that the reflective practice involved in the Lesson Study process and having somebody to share her reflection with was very significant to her.	**Researcher:** Alright.... so what do you think is the most important aspect of this whole process for you? **Interviewee:** Eeeem**,** if I look at this very well, the point where you asked me to look back at what happened in my class in terms of learners' response to questions and the methods I used and all that was something I really valued. Though I do it but not now discussing it with somebody and having a visitor in the class actually made the learners more attentive and I think I valued that because you were able to share somethings about your observation which was a food for taught and I believe I will need to work on that.	Learners more attentive	Benefits of Lesson Study (Improved learners concentration)	Lesson Study experience
		Look back at learners response and teaching method used	Benefits of Lesson Study (Reflection)	
		Discussing with somebody Classroom observation	Collaboration	Teacher collaboration
Martha had initially mentioned that she does not know any teacher outside her school,	**Researcher:** Considering the collaboration aspect of this Lesson Study, how has it affected your professional practice? **Interviewee:** This was a great opportunity to work with a teacher teaching the same grade level within my cluster.	Working together to discuss learners problem	Collaboration	Teacher collaboration

participating in Lesson Study has helped her established a collegial relationship with another teacher from a different school.	You know collaborating with my HOD and the other teacher in my school is something we just spend few minutes to clarify whatever problem it is I have. But now working together with a teacher from another school, we were able to discuss few areas where learners have problems in this knowledge area of electricity and magnetism and I think his approach to the practical demonstration on magnetic field lines were quite helpful. I also think that I have been able to build a network with him which I think is going to be very useful for me in terms of building a professional network outside the school where I teach.	building a professional network outside the school New approach to involving learners in practical Demonstration on magnetic field lines	 Teacher learning	
Martha believes that participating in Lesson Study stimulated her knowledge on the use of the use of reflection to improve her teaching methods rather than using her usual practice which is re-explaining.	**Researcher:** How has participating in this study influenced your classroom teaching practice and knowledge? **Interviewee:** like I said earlier, I do my reflection whenever I have this feeling that I had a bad lesson and I just go back to re explain the lesson again but during our first meeting, Mr Alex's suggestion on the idea of allowing learners to observe, draw and discuss the magnetic field lines around the magnet made me realize that I could develop new ways of teaching the learners the same lesson if I take my time to critically reflect on the method I used in teaching the lesson before and not just re teaching using the same method. I did realize that there were some few things I actually learnt from you and him which probably could have not known on my own. That's why I did less of talking during the discussions so I can critically look into my practice to check if it's on track.	Using participative form of teaching Using critical reflection to develop new teaching methods Personal integration of knowledge	Teacher learning	Impact on practice

Martha believes that the time frame for teaching required content is limited due to several activities; she feels she has to create more time to cover her lessons due to learners' negative attitude and this will not make Lesson Study work.	**Researcher:** Are there any factors that might possibly affect your continuous use or practice of Lesson Study as a teacher? **Interviewee:** I think time is a main factor because our learners struggle with the pace in Physical sciences. For instance, in grade 12, we just introduced organic Chemistry and the time allowed in the CAPS document is not nearly enough to cover all the content that learners need to know. And we have too much public holidays which shortens the term. For instance I asked learners to come for afternoon lessons every Tuesday they gave excuses I changed it to Wednesdays they gave excuses so their attitude to learning might probably not make this work as well if you can understand.	Time Learners difficulties Learners attitude to extra classes	Resources Learners characteristics	Contextual factor

Appendix 19: Lesson Study pair observation for pair B

Lesson Study pair observation protocol for pair B

Group Observed	Lesson Study pair B
Observer	Researcher
Topic	First research lesson (Magnetism)
Date	06/05/2017

Checklist for group observation

	Criteria	**Researcher's comments**
1.	Did the teachers value the contribution of one another and opened to different points of views?	Teachers generally discussed on learners difficulties in Physical sciences. Both teachers believe that learners don't have problem in magnetism.
2.	Teachers demonstrate content and pedagogical knowledge as a group while preparing for the lesson	Their discussion indicates that they are consistent with the important aspects to be taught as they focused on using CAPS document as a guide.
3.	Criticism is constructive and there is collegial challenging of diverse ideas	There was no constructive criticism since discussion was based on agreement of using CAPS document and power point presentations.
4.	Teachers share responsibilities among each other	Martha was reserved and silent in the first meeting so Alex agreed to write the lesson plan.
5.	Teachers identify learners difficulties in the topic and demonstrate knowledge of learners interest	Both teachers believes that learners don't have difficulty on magnetism. Martha indicated that some learners could still struggle with drawing out field line patterns, they both suggested on using question and answer as a way introducing topic to learners.
6.	Teachers manage time	Time was managed since teachers were focused on other activities to be done.

7.	Teachers monitor how they understand information and plan activities	This was done during the planning of this lesson. Lesson contained activities focused on definition and explanation of terms of indicated the CAPS document guide.
8.	Teachers monitors their progress and adjust their processes to become more effective when appropriate	Teachers believed that the lesson was not difficult and requires no adjustment in terms of teaching.
9.	The teachers set out instructional outcomes and determine learning goals	Instructional outcomes and lesson goals were aligned with the CAPS document which is the required standard in the country.
10.	Teachers consider several ways of solving learners perceived difficulties before deciding what method works best	Teachers believed that learners are to be encouraged to continue to reading in order to enable them know how to define basic terms in the lesson.
11.	Teachers design relevant instruction and learners assessment	Learners' instruction and assessment was designed based on teachers' ideas of what the CAPS document specifies.
12.	Connections are made between past learning, current goals and intended applications	They discussed on learners definition of magnets using their previous knowledge from matter and relating it to how objects attract each other in the environment.

Lesson Study pair observation protocol

Group Observed	Lesson Study pair B
Observer	Researcher
Topic	Second research lesson (Electrostatics)
Date	11/05/17

Checklist for group observation

	Criteria	Researcher's comments
1.	Teachers value the contribution of one another and opened to different points of views	Alex valued Martha's idea of using simulations on balloons and static electricity to illustrate concepts of charge transfer, induction, attraction, repulsion, and grounding.
2.	Teachers demonstrate content and pedagogical knowledge as a group while preparing for the lesson	Teachers discussed about what learners should know as indicated in the CAPS document and identified learners' difficulties in the topic based on their classroom experience.
3.	Criticism is constructive and there is collegial challenging of diverse ideas	Teachers constructively solved few questions together and agreed to use the best approach suitable for their respective learners.
4.	Teachers share responsibilities among each other	Alex agreed to write down a brief overview of what the topic should cover as discussions was going on.
5.	Teachers identify learners difficulties in the topic and demonstrate knowledge of learners interest	They discussed on misconceptions between charges and poles as used in magnetism, calculations on forces between charges and charge distribution.
6.	Teachers manage time	Time was effectively managed by the teachers and the researcher
7.	Teachers monitor how they understand information and plan activities	Activities were not monitored since teachers used activities based on CAPS document and learners workbook.
8.	Teachers monitors their progress and adjust their processes to become more effective when appropriate	Teachers monitored their progress based on reflection from lesson 1 on how to stimulate learners interest when teaching a topic.
9.	The teachers set out instructional outcomes and determine learning goals	Instructional outcomes and learning goals were set out based on the CAPS standardized document.
10.	Teachers consider several ways of solving learners perceived difficulties before deciding what method works best	Discussions on use of simulations, videos, class demonstration and problem solving approach
11.	Teachers design relevant instruction and learners assessment	Learners' assessment and instruction were based on the outlined activities in the learners' workbook schedule.
12.	Connections are made between past learning, current goals and intended applications	Reviewing learners' knowledge of atom, types of charges and linking it to what happens when charging an insulator as a form of static

		electricity. Application to calculating charge of electrons from the equation q=eN

Lesson Study pair observation protocol

Group Observed	Lesson Study pair B
Observer	Researcher
Topic	Third research lesson (Electric circuit)
Date	18/05/2017

Checklist for group observation

	Criteria	**Researcher's comments**
1.	Teachers value the contribution of one another and opened to different points of views	Alex valued Martha's idea on the use of simulations which was suggested in previous meetings and also repeated during the planning of this lesson but emphasized on the use of hands on experiment to help learners understand the lesson better.
2.	Teachers demonstrate content and pedagogical knowledge as a group while preparing for the lesson	Both teachers indicated that using power point slides helps in presenting the lesson faster and creates an interesting environment for learners.
3.	Criticism is constructive and there is collegial challenging of diverse ideas	Teachers' ideas were similar to each other in terms of addressing problem solving questions through the use of several examples and relevant activities like homework.
4.	Teachers share responsibilities among each other	Alex documented an overview of what the lesson should cover. Lesson plan was developed by Martha.
5.	Teachers identify learners difficulties in the topic and demonstrate knowledge of learners interest	Teachers identified combined circuit as a problem; Martha suggested using power point to elaborate on how the circuits can be resolved will help learners visualize how to address such circuit combinations.

6.	Teachers manage time	Time was well managed since teachers already knew what they wanted to achieve in the lesson.
7.	Teachers monitor how they understand information and plan activities	This was not observed during this planning.
8.	Teachers monitors their progress and adjust their processes to become more effective when appropriate	Alex indicated that calling out learners as suggested by the researcher could be something he might practice when teaching the lesson again if time permits him to do so.
9.	The teachers set out instructional outcomes and determine learning goals	Teachers planned their instructional outcomes in line with the CAPS document since it is the standard document used for teaching in schools.
10.	Teachers consider several ways of solving learners perceived difficulties before deciding what method works best	Teachers believed that the best approach was for them to use the simplest Mathematical method since they both agreed that their learners are slow to comprehend and struggle with Mathematics
11.	Teachers design relevant instruction and learners assessment	Relevant instruction and assessment used were based on teachers agreement to use the activities from the Doc Scientia textbook
12.	Connections are made between past learning, current goals and intended applications	Connection between learners' previous knowledge and future application was agreed to be established using the question and answer approach.

Appendix 20: Lesson Study lesson plans for pair B

Lesson Study lesson plan on research lesson 1

Teacher's Pseudonym: Alex — Lesson duration: 40 minutes

Date: 4 May 2017 — Grade: 10

Subject: Physical Science — Topic: Magnetism

Sub topic: Magnetic field lines and the Earth's Magnetic field

What is the importance of this topic to the learners?

- This topic lays the foundation for how magnetism works which are used in many everyday objects like speakers and fridge magnets.
- This topic is needed to understand the link between electricity and magnetism to understand how motors and generators work.
- Learners see how earth is protected from harmful radiation from space.
- This lesson is important as learners are to show that earth's magnetic field is essential to sustain life on earth to protect life from harmful particles.

Resources: CAPS Document, textbook (Doc Scientia), work schedule 2017.
Material and Apparatus: Bar Magnets, Iron fillings, paper, Compass, magnets
What is the teaching model/ approach you will use for this lesson? Experiential learning, Direct instruction

What are your Goal(s) / Objective(s) for this lesson? Learners understand what is magnetism, how it is produced, how we can visualize magnetic fields using field lines, how different magnetic fields affect each other and property of magnetic fields. Also,

- Learners know how earth sets up its own magnetic field
- Where the magnetic north and south pole lies
- The importance of earth's magnetic field
- Phenomena caused by earth's magnetic field (the aurora)
- Learners know how a compass works.

What should learners already know (previous knowledge)?

- Electrons: where in atoms they are found and what their movement is.
- What 3 types of magnetism exist?
- Definition of magnetism.
- How magnetic fields are set up.

What should learners know after this lesson? Discussed above as goals above

What are the vocabulary terms associated with this topic?

- Magnetism
- Magnetic field
- Domains
- Electron spin
- Aurorae
- True north and south

Lesson Introduction: Begin by having an open discussion with the class by asking them what they think magnetism is, how long do they think people have known about magnetism and how it is produced. This discussion will only be used to get the learners ideas on these questions first. Learners will also be given compasses and asked what they think the needle is made of and how a compass works.

Learners' class activity	Teachers 'expectation of learners' response
(a) After the intro, explain that magnets are objects that experience a force in the presence of a magnetic field which is invisible. (b) Using Magnets, iron fillings and paper the learners will visualize these field lines for a single magnet, opposing poles and attracting poles of magnets. (c) Using a magnet, learners will determine how compass needle turns when different sides of the magnet face it.	(a) Learners will have to draw what field lines they see, on the board or in their book. As a class, we'll discuss the diagrams. After this, formal notes on field lines and how magnetism is set up will be taken down. (b) Learners should see that opposite poles of the magnet and compass attract which must mean that a compass is a magnet itself.

Closing (How do you wrap up /conclude the lesson): Learners will be given an exercise from their learners' workbook. A short multiple choice test will be given to learners to check their recall and understanding of the topic magnetism.

Teacher's Feedback to learners about the class activity (in terms of correction):

- Learners will be asked to draw the field lines on the board for the class and the class will have to reply if they see the same or different.
- From that the teacher will discuss the conventions of how field lines are drawn.
- Mark homework with the class by doing corrections on the board as learners align with their answers.

Home work: Exercise 9 in Doc Scientia

Teachers reflection on the lesson taught:

- Learners were able to remember what they'd learnt about magnetism from term 1 which helped them make connections easily with the new content.
- Allowing learners to carry out the demonstrations, draw what they saw and discuss the drawings seemed to be successful as learners were able to identify what improvements could be made with the drawings.
- Lesson could have been more successful if a group demonstration was conducted with the learners but due to limited space this was not possible.

Lesson Study lesson plan on research lesson 2

Teacher's Pseudonym: Martha — Lesson duration: 40 minutes

Date: 11 May 2017 — Grade: 10

Subject: Physical Science — Topic: Electrostatics

Sub topic: Tribo electric series, conductors and insulators, the coulomb, charge quantization and the law of conservation of charge

What is the importance of this topic to the learners?
Students understand phenomena such as pulling off a jersey and sparks are seen as well as how conductors and insulators work. They understand what unit charge is measured in (the coulomb).

Resources: CAPS Document, work schedule 2017, Doc Scientia textbook

Material and Apparatus: Plastic rod, cloth, Electroscope, pieces of paper torn into small pieces, metal spheres.

What is the teaching model/ approach you will use for this lesson? Direct instruction, classroom discussion.

What are your Goal(s) / Objective(s) for this lesson?

- Learners understand how electrostatics differ from current electricity
- How objects become charged
- Which objects are more likely to become negatively charge or positively charged
- How conductors and insulators work
- Learners know what unit charge is measured in and how it relates to electrons.
- Learners understand that objects have an integer multiple charges of $1.6x10^{-19}$ and why.
- Learners understand what it means when an object has a charge in coulombs (i.e. that is has gained or lost electrons which have a certain coulomb charge).

What should learners already know (previous knowledge)?

- Real life examples of static electricity
- What are the elementary charges (electron and proton) and their location in the atom
- How objects can be charged.
- Electrons are negatively charged and protons positively charged.
- Which charges (protons and electrons) are free to move and why.

What should learners know after this lesson? Discussed above as goals above

What are the vocabulary terms associated with this topic?

- Tribo electric series
- Induction
- Conductor
- Insulator
- Quantization
- Coulomb
- Net charge

Lesson Introduction: Discuss examples of static electricity and what is meant by the term. After explanation, I begin by discussing two metal spheres that each has a different charge due to each having a specific number of protons and electrons. The objects are touched and then separated. We will look at what happens to the total charge of both objects together as well as the charge of each object before and after touching and then being separated.

Learners' class activity	**Teachers 'expectation of learners' response**
• Discuss how objects are charged and ask learners how we can know which objects will become positively charged and which negatively. • Show friction charging with rod and cloth and induction and contact charging with electroscope. • Using the metal spheres, I will show the learners what we mean by charge being conserved during a physical change like	• Learners may think positive charge can move. • Learners should be able to explain which charges move from one sphere to another (i.e. electrons move, not protons, because they are free to move). • Learners will determine that the negative charge or electrons spread out equally on either sphere. With regards to charge quantisation, learners begin to see that the charge on the sphere is just a multiple value of the $1.6x10^{-19}$ charge. I will then tell them that this multiple can only be an integer

touching the spheres together and then separating them. • To explain quantization of charge, I will have shown the learners what the charge on a single electron and proton are and by demonstration using a metal sphere, ask them what the charge in coulombs is if I keep adding an electron to the sphere.	multiple (whole, positive numbers) because we cannot have a fraction of an electron.

Closing (How do you wrap up /conclude the lesson): Possibly show learners the van der graaf generator and how it works. Learners complete Ex 10 in their textbooks. During this time I will walk around assisting any learner who needs help.
Teacher's Feedback to learners about the class activity (in terms of correction): Revisit the atom. I will mark the exercise with the learners the following period. Learners need to give me the first couple of answers to each question and once I see that they know how to answer it, I will give them the answers to the rest of the questions.
Home work: Ex 10 Doc Scientia
Teachers reflection on the lesson taught: After stressing the idea of charge quantization by using the example of placing a single electron on an object one at a time and asking the learners what the charge on the object will be, the learners showed that they understood the Principle of Quantization of Charge. Through marking the exercise, learners also showed that they grasped the concepts.

Lesson Study lesson plan on research lesson 3

Teacher's Pseudonym: Martha — Lesson duration: 40 minutes

Date: 18 May 2017 — Grade: 10

Subject: Physical Science — Topic: Electric circuits

Sub topic: Voltage, current, resistance, trends in voltage and current in series and parallel circuits.

What is the importance of this topic to the learners? • All electronics contain circuits which people come into contact with every day and it is important for learners to know how simple circuits work. • Learners gain practical experience of how to set up circuits with regards to series and parallel circuits. • Learners know how to set-up circuit components such as ammeters and voltmeters.
Resources: CAPS Document, Work schedule 2017, Doc Scientia textbook **Material and Apparatus:** Circuit board set, Grade 10 Circuits Practical Form. **What is the teaching model/ approach you will use for this lesson?** Direct Instruction, classroom discussion, experiential learning.
What are your Goal(s) / Objective(s) for this lesson?

- Learners understand what voltage, current and resistance are and how to calculate them.
- Learners understand the concept of EMF.
- Learners understand why batteries go flat.
- Learners know how conventional current and electron flow arise and why two current systems exist.
- Learners can identify different circuit components.
- Learners are able to set up parallel and series circuits.
- Learners are able to use ammeters and voltmeters correctly to take readings of a circuit.
- Learners are able to explain trends with regards to voltage and current in a series versus a parallel circuit.

What should learners already know (previous knowledge)?

- Electrons are negatively charged and protons positively charged.
- Which charges (protons and electrons) are free to move and why.
- The composition of metals and their "sea" of delocalized electrons.
- Chemical reactions (to explain how a battery works)
- How to draw circuit diagrams.
- How to set up a voltmeter and ammeter in a circuit.
- The difference between parallel and series circuits.
- Trends in voltage and current in series and parallel circuits.

What should learners know after this lesson?

Stated as goals above

What are the vocabulary terms associated with this topic?

- Voltage, potential difference, EMF
- Current
- Resistance
- Charge
- Parallel circuit.
- Series circuit.

Lesson Introduction:

I begin by discussing earth's gravitational potential field and likening it to the electric potential field and how in that field, objects can be given energy like electrons in a circuit. From this I will explain current and how it is similar to the concept of frequency in waves. Then randomly divide the class up into groups. Then explain the practical form drawing attention to the aim of the experiment as well as what readings need to be taken. Teacher will discuss that the practical is broken-up into two parts: series and parallel circuits. Then ask learners to also take note of the brightness of the bulbs in both experiments. Learners are then left to set up the circuits.

Learners' class activity	**Teachers 'expectation of learners' response**
I will ask the class where the charges in a circuit come from, in which direction they flow and if there are any misconceptions, I will remind them of the composition of metals and why they are good conductors of electricity. • Learners are to set up series circuits and take readings while teacher move from group to group checking how they have set the circuits up and how they are taking readings.	• Learners will think that the charges in a circuit originate from the battery. • Learners will at first think that charges flow from the positive terminal of a battery to the negative. • Learners struggle a lot with setting up parallel circuits. Teacher assist them by showing them how to trace the circuit with their fingers along the wires to determine if they have set up a parallel circuit since in a parallel circuit, your fingers will need to split at some point where the parallel

	connection begins. Learners also struggle a lot with taking current and voltage reading as they forget how to set up these devices. This is especially apparent with parallel circuits. Using the method of tracing the circuit with their fingers, the teacher will show them where to place the ammeter or voltmeter so that they can take various readings such as the current through bulb 1 versus the total current in the circuit with regards to a parallel circuit.

Closing (How do you wrap up /conclude the lesson):

I will try to review the following point**:**

- Correct definition of current, ampere and correct application to solving calculations
- A voltmeter must always be connected in series while an ammeter must always be connected in parallel across a circuit
- Resistors in series are potential dividers, flow of current remains the same and total resistance in a series circuit increases
- Resistors in parallel are current dividers, have the same potential difference and total resistance across a parallel circuit decreases. Learners must also know that the effective resistance of a parallel resistor is lower than the resistance in the smallest resistor. Importance of substituting without changing subject of the formula
- Check the readings of the different groups and see that they have answered question 4 and 5 of the experiments. Also ask them to begin discussing in their groups what the variables of the experiment are and assist them if needed.

Teacher's Feedback to learners about the class activity (in terms of correction):

There should be an open discussion with the class while explaining the various concepts such as electromotive force. Teacher will use these discussions to determine what misconceptions learners have and why, and then correct them by asking various questions so that they may become aware of their misconceptions. Mark homework with the class by doing corrections on the board as learners align with their answers.

Home work:

- Ex 13, Page 133
- Learners have to complete a Scientific Report with regards to the practical during class.

Teachers reflection on the lesson taught:

The example of raising a pen and thus it gaining potential energy seemed effective as a way of likening it to a battery that provides energy to charges. Discussing EMF with the class also gave learners the opportunity to think where energy is used up in a circuit which allowed the teacher to address the resistance of wires which a learner brought up. I however do need to do examples using Ohm's Law as it is clear that learners struggle to apply it to circuits, especially combination circuits.

Appendix 21: Classroom observation for Lesson Study pair B

Appendix 21A: Alex's Lesson observation transcription

School	Roderick's high school
Date of lesson observation	02 / 05 / 2017
Subject	Physical sciences
Grade	10-6
Number of learners	30
Topic Observed	Magnetism (Magnetic field lines)
Lesson time	9:15 – 11: 20

Checklist for teacher's classroom lesson observation

Observed Element	**Criteria**	**Evidence**
Assessing learners learning	Did the teacher assess learners' previous knowledge?	Yes, by asking learners to define magnetism based on their previous knowledge from first term work on matter.
	Did the teacher check for learners understanding of the lesson taught?	Teacher engaged learners in interactive learning which does not require him to keep asking if learners understand or not. Learners also asked questions when they are confused.
Instructional delivery	Did the teacher present an overview of the lesson?	No presentation on lesson overview
	Did the teacher manage the disruptive behaviours of learners?	Learners were attentive all through the lesson.
	Did the teacher engage the learners in a whole class activity?	Yes. During lesson introduction, learners engaged in a discussion about what was observed during the teacher's demonstration on magnetic field lines.
	Did the teacher present the lesson to meet the planned objectives?	Yes, lesson was presented according to planned Lesson Study template.
	Did the teacher clarify learners' misconceptions during the teaching?	Yes, by adequately responding to learners' questions on what learners feel they don't understand.
	Did the teacher demonstrate knowledge of various teaching practices?	Yes, he used demonstration, explanation, question and answer method during his teaching.

	Did the teacher integrate examples from real world into the teaching?	This was not observed during the teaching.
	Did the teacher emphasize important points while teaching?	Teacher emphasized on the movements of magnets exiting from the North and entering through the South. Also emphasized that not all metals can be magnetized.
	Did the teacher use relevant activities to clarify key concepts?	He used relevant illustration on how to create a magnet by placing a magnet over another object in the same direction.
Classroom interaction	Did the teacher encourage small group/ paired activities among learners?	No small group or paired activities was done in this lesson. Learners were only given the opportunity to observe their teacher's demonstration on how magnetic field is created.
	Did the teacher encourage individual /independent work among learners	Yes, by asking learners to observe the magnetic field line in the teacher's demonstration and draw out what was observed after which they explained what they saw.
	Did the teacher write key terms on the board?	No. He only wrote basic definitions, points to note and diagrammatic illustrations on the board.
	What lecturing activities did the teacher use in disseminating knowledge?	Demonstration, Explanation, question and answer.
	Did the teacher create a good classroom environment for teaching the lesson?	Yes, the demonstration of magnetic field at the beginning of the lesson motivated learners interest in the topic and probably made learners attentive.
	Did the teacher relate well with the learners?	Yes, he allowed learners to ask questions and re responded to their questions appropriately.
	Did the teacher support learners learning?	Through the demonstration activities and answering of learners' questions.
	Did the teacher encourage learners to participate in the teaching and learning process?	Through question and answer.
	Did the teacher effectively manage the classroom?	The classroom environment was well managed.

	Did the teacher create an environment of interest for learners while teaching this lesson?	Yes, through demonstration and definition of basic terms.
Teacher's knowledge	Did the teacher demonstrate knowledge of required concepts in the subject matter?	Knowledge of content was well demonstrated by the teacher.
	Did the teacher conduct practical activities?	No practical activities conducted by learners in this lesson; only teacher demonstration.
	Was the content of the lesson presented to meet learners need?	Yes, as outlined in the CAPS document and Lesson Study plan template.
	Is the teacher committed and enthusiastic about the lesson and learners learning	Yes, teachers did more than one demonstration activity to enhance learners understanding of how magnetic field is created with single magnets, opposite and same side of poles of magnets facing each other.
	Did the teacher show empathy towards learners' inability to understand the lesson?	Yes, by ensuring that he answers learners questions appropriately which gives the learners a kind of satisfaction.
	Did the teacher provide learners with accurate feedback?	Feedback was appropriately given by answering questions and also providing answers as corrections to activities in learners workbook.

School	Roderick's high school
Date of lesson observation	05/05/2017
Subject	Physical sciences
Grade	10-6
Number of learners	30
Topic Observed	Electrostatics
Lesson time	7:55 – 8:35

Checklist for teacher's classroom lesson observation

Observed Element	Criteria	Evidence

Assessing learners learning	Did the teacher assess learners' previous knowledge?	Yes. Through question and answer by asking them their understanding of current and static electricity from their Natural sciences.
	Did the teacher check for learners understanding of the lesson taught?	The question and answer method indicated that he was trying to see how learners understood the concepts in the topic.
Instructional delivery	Did the teacher present an overview of the lesson?	Yes. By asking the learners about their understanding of the word electrostatics and thereafter explaining the word to learners.
	Did the teacher manage the disruptive behaviours of learners?	Learners were attentive whenever the teacher is explaining or writing notes on the board
	Did the teacher engage the learners in a whole class activity?	Yes. when explaining the concept of net charge teacher allowed learners to jointly solve few problems and asks them to interpret their answers.
	Did the teacher present the lesson to meet the planned objectives?	The lesson was well presented according to the curriculum and lesson template design.
	Did the teacher clarify learners' misconceptions during the teaching?	Yes. By responding to learners' answers
	Did the teacher demonstrate knowledge of various teaching practices?	Yes. He used illustrations, explanation method which comes in the normal lecture approach questions and answers
	Did the teacher integrate examples from real world into the teaching?	This was not observed during his teaching
	Did the teacher emphasize important points while teaching?	Important points were written on the board as teacher explains the lesson
	Did the teacher use relevant activities to clarify key concepts?	Through explanation of key concepts and illustrations
Classroom interaction	Did the teacher encourage small group/ paired activities among learners?	This was not done in the lesson.
	Did the teacher encourage individual /independent work among learners	The question and answer method was one way of encouraging learners to individually think and response to teacher's questions asked.

	Did the teacher write key terms on the board?	Yes
	What lecturing activities did the teacher use in disseminating knowledge?	Explanation
	Did the teacher create a good classroom environment for teaching the lesson?	Learners were attentive and the classroom was silence which is an indication of a good learning environment.
	Did the teacher relate well with the learners?	Yes; by adequately responding to their questions.
	Did the teacher support learners learning?	Learners learning was well supported during the teaching.
	Did the teacher encourage learners to participate in the teaching and learning process?	Yes. Through the question and answer section
	Did the teacher effectively manage the classroom?	The classroom was well managed by the teacher
	Did the teacher create an environment of interest for learners while teaching this lesson?	Using concepts of atom and molecules to explain charges in an object interested the learners.
Teacher's knowledge	Did the teacher demonstrate knowledge of required concepts in the subject matter?	Teacher was confident of his teaching.
	Did the teacher conduct practical activities?	No practical activity was done in this lesson.
	Was the content of the lesson presented to meet learners need?	Lesson content was well presented and well explained
	Is the teacher committed and enthusiastic about the lesson and learners learning	He used various methods to ensure that learners understood what he was teaching them.
	Did the teacher show empathy towards learners' inability to understand the lesson?	This was not observed by the researcher
	Did the teacher provide learners with accurate feedback?	He responded adequately to their answers and also provided corrections to activities in learners' workbook.

School	Roderick's high school

Date of lesson observation	19/5/2017
Subject	Physical sciences
Grade	10-6
Number of learners	30
Topic Observed	Electric circuit
Lesson time	11:20 – 12:40

Checklist for teacher's classroom lesson observation

Observed Element	**Criteria**	**Evidence**
Assessing learners learning	Did the teacher assess learners' previous knowledge?	I believe this was done through question and answer and when reviewing learners knowledge of the meaning of frequency.
	Did the teacher check for learners understanding of the lesson taught?	During the class activity he assisted some learners by clarifying difficult concepts indicated by the learners.
Instructional delivery	Did the teacher present an overview of the lesson?	No presentation of lesson overview. He presented a power point slide.
	Did the teacher manage the disruptive behaviours of learners?	Learners were attentive during teaching
	Did the teacher engage the learners in a whole class activity?	Learners were given class activity exercise from their workbook which gave them the opportunity to involve in a class discussion.
	Did the teacher present the lesson to meet the planned objectives?	The lesson was presented to meet the Lesson Study planned objectives and CAPS document
	Did the teacher clarify learners' misconceptions during the teaching?	By responding to learners questions during the teaching and practical section
	Did the teacher demonstrate knowledge of various teaching practices?	He used demonstration, illustration, direct teaching
	Did the teacher integrate examples from real world into the teaching?	No, he taught according to scientific concepts and directly focused on the teaching.

	Did the teacher emphasize important points while teaching?	He repeatedly indicated that learners should always take note of some facts for exam purposes.
	Did the teacher use relevant activities to clarify key concepts?	Activities were based on simple calculations which were minimal in number.
Classroom interaction	Did the teacher encourage small group/ paired activities among learners?	Small group activities was done in form of practical experiment.
	Did the teacher encourage individual /independent work among learners	Individual work was based on homework and class activity given to learners.
	Did the teacher write key terms on the board?	Key definitions and formula were written on the board.
	What lecturing activities did the teacher use in disseminating knowledge?	Direct instruction, demonstration, practical activities.
	Is the teacher able to create a good classroom environment for teaching the lesson?	He encouraged and facilitated good interaction among learners through the question and answer approach
	Did the teacher relate well with the learners?	The communication process was cordial between the teacher and his learners.
	Did the teacher support learners learning?	By adequately responding and clarifying learners questions during the teaching and the practical activity.
	Did the teacher encourage learners to participate in the teaching and learning process?	Yes, through the question and answer; and also allowing learners to be involved in the practical activity on circuit connection.
	Did the teacher effectively manage the classroom?	Classroom environment was well managed.
	Did the teacher create an environment of interest for learners while teaching this lesson?	He did not relate the topic to real life experience but I think going round to check learners work was a way of checking learners' interest in the lesson.
Teacher's knowledge	Did the teacher demonstrate knowledge of required concepts in the subject matter?	His teaching was effective and he was able to explain key concepts without reading from textbooks or slide.
	Did the teacher conduct practical activities?	yes

	Was the content of the lesson presented to meet learners need?	yes
	Is the teacher committed and enthusiastic about the lesson and learners learning	He was confident while teaching and he always asked learners during the practical if they were confused or what they have been able to do.
	Did the teacher show empathy towards learners' inability to understand the lesson?	Yes, when he observes that learners are finding it difficult to connect the circuit, he used his finger to illustrate what should be connected to what and how learners are to know if their connection is right or wrong.
	Did the teacher provide learners with accurate feedback?	Feedback was given in terms of correction though not marked by the teacher.

Appendix 21B: Marha's Lesson observation transcription

School	Duncan secondary school
Date of lesson observation	09 / 05 / 2017
Subject	Physical sciences
Grade	10 Key 2
Number of learners	35
Topic Observed	Magnetism (Magnetic field lines)
Lesson time	07:55 – 08: 35

Checklist for teacher's classroom lesson observation

Observed Element	**Criteria**	**Evidence**
Assessing learners learning	Did the teacher assess learners' previous knowledge?	Questions were asked on propagation of electromagnetic waves
	Did the teacher check for learners understanding of the lesson taught?	She repeatedly asked if learners understood, indicated that learners can call her attention whenever they don't understand what she was saying.
Instructional delivery	Did the teacher present an overview of the lesson?	Lesson overview was presented through a question and answer approach
	Did the teacher manage the disruptive behaviours of learners?	Learners were quiet and attentive during the teaching process.
	Did the teacher engage the learners in a whole class activity?	Whole class activity was observed when learners were asked to observe and discuss magnetic field patterns
	Did the teacher present the lesson to meet the planned objectives?	Yes.
	Did the teacher clarify learners' misconceptions during the teaching?	By responding to learners questions; for instance when she corrected learners that the chemical name for a solid iron is Fe and not Fe_3 as some learners have answered.
	Did the teacher demonstrate knowledge of various teaching practices?	She was very descriptive in her teaching, Yes.

	Did the teacher integrate examples from real world into the teaching?	All explanations were based on scientific concepts except when a learner interpreted his understanding of North pole using Polokwane as a direction.
	Did the teacher emphasize important points while teaching?	Yes, she emphasized on the definition and characteristics of a magnetic field.
	Did the teacher use relevant activities to clarify key concepts?	She used basic illustrations and explanation of her power point slides.
Classroom interaction	Did the teacher encourage small group/ paired activities among learners?	Group activity was done during practical demonstration by learners on magnetic field patterns.
	Did the teacher encourage individual /independent work among learners	Based on group work, learners were to individually decide on the direction of magnet when tied by a thread or string.
	Did the teacher write key terms on the board?	No, key terms were indicated in her power point slides and not written on the board.
	What lecturing activities did the teacher use in disseminating knowledge?	Explanation, practical demonstration, note review, illustration
	Did the teacher create a good classroom environment for teaching the lesson?	Classroom environment was quiet and conducive for learning during the teaching process but noisy during demonstration as expected from learners.
	Did the teacher relate well with the learners?	Adequate communication and collegiality was observed between the teacher and her learners
	Did the teacher support learners learning?	Through practical demonstrations and also allowed learners to discuss their observation.
	Did the teacher encourage learners to participate in the teaching and learning process?	Yes, through practical demonstration and also involving learners in a question and answer section.
	Did the teacher effectively manage the classroom?	Classroom was well managed and neatly arranged.
	Did the teacher create an environment of interest for learners while teaching this lesson?	By giving learners magnets and the use of power point. Learners echoed wahooo, when the projector was on.
Teacher's knowledge	Did the teacher demonstrate knowledge of required concepts in the subject matter?	Yes, this was observed during her explanation even though she repeatedly read out her notes from the slides before explaining.

	Did the teacher conduct practical activities?	Practical demonstration was conducted during this lesson.
	Was the content of the lesson presented to meet learners need?	Lesson content was well presented to meet learners need.
	Is the teacher committed and enthusiastic about the lesson and learners learning	She repeatedly asked the learners to ask question if they don't understand.
	Did the teacher show empathy towards learners' inability to understand the lesson?	By correcting learners mistakes based the questions that were asked.
	Did the teacher provide learners with accurate feedback?	Yes, adequately responded to learners' questions and correction to homework.

School	Duncan secondary school
Date of lesson observation	16 / 05 / 2017
Subject	Physical sciences
Grade	10 Key 2
Number of learners	35
Topic Observed	Electrostatics
Lesson time	08:35 – 09: 45

Checklist for teacher's classroom lesson observation

Observed Element	**Criteria**	**Evidence**
Assessing learners learning	Did the teacher assess learners' previous knowledge?	Teacher reviewed learners' knowledge of atom and it's constituent.
	Did the teacher check for learners understanding of the lesson taught?	She was time conscious and focused on covering her lesson since exams were fast approaching.
Instructional delivery	Did the teacher present an overview of the lesson?	Martha did not present an overview of the lesson before her teaching.

	Did the teacher manage the disruptive behaviours of learners?	Learners were attentive and the learners were well behaved during the teaching process.
	Did the teacher engage the learners in a whole class activity?	This was observed during teacher's use of question and answer approach in assessing learners previous knowledge
	Did the teacher present the lesson to meet the planned objectives?	Teacher's classroom teaching was presented as discussed during the Lesson Study planning section.
	Did the teacher clarify learners' misconceptions during the teaching?	She was able to differentiate the types of charges and elaborately explained solved examples on charge distribution and forces between charges.
	Did the teacher demonstrate knowledge of various teaching practices?	She used explanation, simulations, practical demonstration and problem solving approach.
	Did the teacher integrate examples from real world into the teaching?	This was not observed during her teaching on his lesson
	Did the teacher emphasize important points while teaching?	She clearly stated that learners must know how to state the law of conservation of charge and its intended application to solving questions.
	Did the teacher use relevant activities to clarify key concepts?	She used activity from simulation to clarify the concept of charge transfer and charging by induction.
Classroom interaction	Did the teacher encourage small group/ paired activities among learners?	No group or paired activities but teacher demonstrated an experiment to class as a group and asked for their response as group.
	Did the teacher encourage individual /independent work among learners	Individual / independent work was given to learners in form of home work
	Did the teacher write key terms on the board?	All key terms were on teacher's slides which was projected on the board.
	What lecturing activities did the teacher use in disseminating knowledge?	Note reviewing from her slides and explanation.

	Did the teacher create a good classroom environment for teaching the lesson?	Classroom environment was conducive and well managed for the teaching and learning process.
	Did the teacher relate well with the learners?	She had a good interaction and relationship with her learners.
	Was the teacher able to support learners learning?	By correcting learners' wrong answers to questions asked.
	Did the teacher encourage learners to participate in the teaching and learning process?	This was observed through question and answer; and her ability to correct learners' wrong answers to questions asked.
	Did the teacher effectively manage the classroom?	The classroom was well spaced and effectively managed by the teacher
	Did the teacher create an environment of interest for learners while teaching this lesson?	The simulation captured learners interest in the lesson
Teacher's knowledge	Did the teacher demonstrate knowledge of required concepts in the subject matter?	Yes
	Did the teacher conduct practical activities?	Practical demonstration was conducted by the teacher
	Was the content of the lesson presented to meet learners need?	Lesson content was presented to meet learners need as indicated in the CAPS document.
	Is the teacher committed and enthusiastic about the lesson and learners learning	She was enthusiastic about teaching the lesson and committed to ensuring that learners understand the lesson.
	Did the teacher show empathy towards learners' inability to understand the lesson?	She showed empathy towards learners understanding by asking those who don't understand to meet her after the lesson for re-explanation.
	Did the teacher provide learners with accurate feedback?	Correction was done on solved examples and homework given to learners.

School	Duncan secondary school
Date of lesson observation	23 / 05 / 2017
Subject	Physical sciences
Grade	10 Key 2
Number of learners	35
Topic Observed	Electric circuit

Lesson time	09:45– 10: 55

Checklist for teacher's classroom lesson observation

Observed Element	**Criteria**	**Evidence**
Assessing learners learning	Did the teacher assess learners' previous knowledge?	By asking questions on important things needed in electrical circuit.
	Did the teacher check for learners understanding of the lesson taught?	This was observed when she asked if a circuit can run without a switch.
Instructional delivery	Did the teacher present an overview of the lesson?	The lesson overview was indicated on her power point slide
	Did the teacher manage the disruptive behaviours of learners?	Learners were attentive during the teaching
	Did the teacher engage the learners in a whole class activity?	Through asking and responding to questions
	Did the teacher present the lesson to meet the planned objectives?	Lesson was theoretically presented to meet planned objectives. But not in terms of planned practical
	Did the teacher clarify learners' misconceptions during the teaching?	She explained to learners that circuit cannot run when the switch is opened.
	Did the teacher demonstrate knowledge of various teaching practices?	Yes
	Did the teacher integrate examples from real world into the teaching?	No
	Did the teacher emphasize important points while teaching?	Emphasized on definitions of key terms and substitution of Mathematical values before solving any calculations. Also indicated the importance of units.
	Did the teacher use relevant activities to clarify key concepts?	She used very few activities for problem solving based on her power point lecture note.
Classroom interaction	Did the teacher encourage small group/ paired activities among learners?	No small group or paired activities was observed in this lesson

	Did the teacher encourage individual /independent work among learners	Individual activities were given to learners in form of home work from learners exercise and alternative to practical.
	Did the teacher write key terms on the board?	Teacher used power point presentation but presented key differences between series and parallel circuit in a tabular form on the board.
	What lecturing activities did the teacher use in disseminating knowledge?	Re teaching, lecture presentation, use of visual aids (power point)
	Did the teacher create a good classroom environment for teaching the lesson?	Classroom environment was silent and good for teaching the lesson
	Did the teacher relate well with the learners?	Teacher learner relationship was well managed
	Did the teacher support learners learning?	By correcting learners' mistakes on questions asked.
	Did the teacher encourage learners to participate in the teaching and learning process?	Through teacher directed question and answer,
	Did the teacher effectively manage the classroom?	Teacher manages the classroom proactively and calmly
	Did the teacher create an environment of interest for learners while teaching this lesson?	Teacher's use of technology equipment (projector) captivated learners' interest and enhanced teacher's lesson presentation and delivery.
Teacher's knowledge	Did the teacher demonstrate knowledge of required concepts in the subject matter?	Yes, by properly explaining each concepts to learners.
	Did the teacher conduct practical activities?	No practical activity was conducted in this lesson.
	Was the content of the lesson presented to meet learners need?	Lesson content was presented as outlined in the CAPS document and discussed during the planning meeting.
	Is the teacher committed and enthusiastic about the lesson and learners learning	She checked for learners understanding through verbal questioning.
	Did the teacher show empathy towards learners' inability to understand the lesson?	By asking learners who don't understand to call her attention back to the concept.
	Did the teacher provide learners with accurate feedback?	Teacher provided corrections to home work on the board and instructs learners to align the corrections with their answers.

Appendix 22: Document Analysis of Lesson Study pair B

Document Analysis

Teacher's Pseudonym: Martha

School (Pseudonym): Duncan secondary school

Date collected: March 2017

Document analysis Guide: Teachers document (lesson plan)

Significance of this document: To know how teachers originally plan and prepare for their lessons.

Criteria	Comments
Teacher's description of how the lesson fits into a larger curricular unit	✓ Description of how lesson fits into a larger picture did not reflect in the teacher's original lesson plan.
Activities in teacher planning that assessed or stated learners' prior knowledge	✓ No outline of activities assessing or stating learners previous knowledge in teachers lesson plan
Outline of inquiry methods to be used while teaching the lesson	✓ Inquiry and teaching methods were captured in the core knowledge area where teacher is to describe, discuss, explain and give examples during the teaching process.
Outline of teacher's expectation of what learners should know and be able to do at the end of lesson	✓ Teacher's original lesson plan did not outline the learning objectives in terms of what learners should know and be able to do at the end of the lesson.
Instructional materials teacher's used in the class while teaching the lesson	✓ Lesson preparation did not reflect the instructional materials to be used by teacher during the teaching process.
Content/procedure standard	✓ Lesson plan captured lesson content on core knowledge area that learners are expected to know.
Teacher's feedback to learners	✓ No provision for feedback or strategies to check for learners understanding of the lesson taught in teacher's original lesson plan.
Teacher's wrap up/ conclusion	✓ No indication on how to wrap up or conclude the lesson in her lesson plan
Planned learners' assessment	✓ Assessment methods to be used such as class test, control test and project was indicated in the lesson plan.
Notes for teachers to reflect on the lesson taught	✓ Lesson plan did not capture teacher's note for reflection on learners learning and lesson taught.

Document Analysis

Teacher's Pseudonym: Alex

School (Pseudonym): Roderick's high school

Date collected: March 2017

Document analysis Guide: Teachers document (lesson plan)

Significance of this document: To know how teachers originally plan and prepare for their lessons.

Criteria	**Comments**
Teacher's description of how the lesson fits into a larger curricular unit	✓ Not captured in the original lesson plan
Activities in teacher planning that assessed or stated learners' prior knowledge	✓ Teacher did not indicated any activity that can be used in assessing learners' prior knowledge in his personal lesson plan.
Outline of inquiry methods to be used while teaching the lesson	✓ This was not indicated in the original lesson plan.
Outline of teacher's expectation of what learners should know and be able to do at the end of lesson	✓ Not captured in teachers original lesson plan.
Instructional materials teacher's used in the class while teaching the lesson	✓ Not captured in teacher's original lesson plan.
Content/procedure standard	✓ Lesson plan captured teacher's prepared lesson content to be given to learners.
Teacher's feedback to learners	✓ No indication of expected feedback to be given to learners in teacher's original lesson plan.
Teacher's wrap up/ conclusion	✓ Teacher did not indicate how to wrap up or conclude his teaching in his lesson plan.
Planned learners' assessment	✓ Teacher did not indicate how to assess his learners in the original lesson plan presented.
Notes for teachers to reflect on the lesson taught.	✓ This was not captured in Alex's lesson plan.

Appendix 23: Participants' reflective writings

Appendix 23A: Lesson Study pair A

Mbali's reflective writing

2016. [redacted]

Day 9: I am interested in how this study works but can't use it with this present learners.

Initially I thought I don't like people from outside coming to see what I do in the class but your presence in my class was very helpful and built my confidence to teach in front of other's I don't know.

The time allocated for teaching is small but I think I can try involve my learners in some class discussions next time.

Relating scientific concepts using real world applications promotes better understanding with higher level thinking skills and high learners engagement in class.

This lesson study forced me into working with another teacher and with the motivation and effort you put I don't think I have the feeling or need to isolate my teaching and it has also encouraged me to use more of learners participation in my lessons.

Lenox's reflective writing

[redacted]

Lesson study has shown me different ways to incorporate vocabulary into my lessons

This Collaborations efforts needs to be an ongoing form of practical teacher training so as to help both the old and new educators build a work relationship status - quo.

This training has helped me create learning experiences that now allows me to present meaningful Content to my learners.

I have learnt other ways of assessing learners and not just by the formal way which everybody is adapted to.
With the help of other teachers in my class, learners can be assessed based on their reactions and expressions to what I teach. And also giving Continuous assessment and providing corrective feedback is very important.

Encouraging Collaborative learning among learners will help learners to develop average to good Interpresonal and Communication skills which can give / yield better academic results.

Appendix 22B: Lesson Study pair B

Martha's reflective writing

[redacted]

Basically, I only reflect when I feel my lesson is bad but parcitipating in this study has made me realise that I can use the reflection to develop another way of teaching the same content for instance I re-teach content using explanation approach repiatedly but when I was teaching magnetism my partner made me understand that I could let learners observe, discuss and draw the field lines which was something I probably would not have thought if I was preparing for the lesson alone.

-> I appreciate the opportunity of having somebody in my class during my teaching and we were later able to discuss what the visitor observed about the learning of the learners. I think it is a great platform discussing how the learners are learning from another persons point of view

-> This also could be an opportunity to bound a network with other teachers from other schools, if this can be done within clusters because I really don't know teachers outside my school.

Alex's reflective writing

My reflection on what I have gained working with you on this study.

1. Discussions with you made me realize that I just teach my lessons direct based on theoretical scientific concepts without using some rea -life examples to capture the learners' interest in the lesson. I believe that discussing with you and the other teacher has helped me understand the importance of relating the theoretical aspect of the lesson to its application in daily life challenges and things around us which could be used to stimulate or capture learners interest in the subject and I believe that could make the teaching of the lesson more fun to learners as you mentioned.

2. I have seen and used different types of lesson plan but I happen to find the lesson plan template you gave to me a bit challenging because I had to struggle through the writing process especially when thinking about teacher's expectation from learners. It got me thinking all through and I learnt something new from the lesson plan which is when preparing for my lessons, I need to understand how my learners will respond to questions asked and therefore prepare my feedback to address whatever it is I already know they will say which could be right or wrong. It's like I should think like my learners.

3. I was surprised by how much the learners could pay attention to the lesson when I was teaching and I think that was because you were present in the class. Their level of concentration increased because of having a different face in the class. The whole process is an interesting one which has helped me learn more about the way I teach using the reflection process involved.