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Evolution of my subject matter knowledge for teaching energy resources and its uses in Grade 11 : self study.

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CHAPTER 1

1.1. Introduction.

Curriculum transformation has been a challenging issue in many countries and to everybody involved in education. However, the legacy of apartheid has aggravated the problem in South Africa, leaving schools with poorly resourced and under-qualified educators. With the implementation of the National Curriculum Statement (NCS) in South Africa in 2006 in grade 10, the educator's uncertainty in the classroom has increased, especially when new teaching strategies must be applied and new topics taught. The intention of the new curriculum is to encourage teachers to be "mediators of learning, interpreters and designers of learning programmes and materials, researchers and lifelong learners, community members, assessor and subject specialists" (NCS document, 2003 p.6). To be a subject specialist, the teacher must have a sound subject matter knowledge as well as knowledge of instructional strategies (Shulman, 1986).

The development of educators' skills in order to implement the new curriculum has taken the form of workshops and a 'one size fits all' approach (Rogan and Grayson, 2003: p 1172). The situation in South Africa was that educators were involved in NCS workshops that were predominantly a one-week orientation programme covering technical issues only. The educators were not involved in the development of the curriculum, but were merely asked to implement the curriculum. Rogan & Grayson (2003: p 1202) proposed that "all role players, but especially those who are more directly involved, need an opportunity to reconceptualise the intended changes in their own terms and for their own context". For optimum curriculum implementation, educators should be optimally involved in the process of developing the curriculum (Carl 2005). The new curriculum contained many new topics and the educators received little help with subject matter knowledge. Therefore, the present study focuses on how I implement the teaching of a new topic in the National Curriculum Statement.

1.2. Context of the study.

The study was conducted in the context of implementing a new approach to the curriculum, which is described in the National Curriculum Statement that was introduced in grade 10 in 2006 (NCS document, 2003). The curriculum was gazetted in 2003, to be introduced in

phases i.e. 2006 in grade 10, 2007 in grade 11 and 2008 in grade 12. In all three grades it included new topics. One of the aims of the NCS is enhancing understanding of technological applications, of Physical Science which should be used responsibly towards social, human, environmental and economic development both in South Africa and globally (Department of Education, 2005: p10). In particular, this aim was to be fulfilled in the context of "chemical systems" in Physical Science curriculum a new knowledge area prescribed by NCS. If learners are to achieve the aims set by NCS they must demonstrate achievement of the three learning outcomes as prescribed, which must be covered within a period of three years. The three learning outcomes are as follows:

- LO 1: Scientific inquiry and problem solving skills
- LO 2: Constructing and applying scientific knowledge
- LO 3: The nature of science and its relationships to technology, society and the environment (NCS Document, 2003).

The content and contexts are used as means of achieving learning outcomes. The knowledge area chemical system was predominantly introduced to address learning outcome three.

According to the Department of Education (2007) document, chemical systems as one of the knowledge area, is described as a new invention and aims at taking chemistry out of the school classroom and provide learners with an experience of real life. It aims at giving learners an opportunity of learning about the environment and what we do to the environment. Teaching of chemical systems will provide learners with an opportunity to explore real life situations. Human rights, inclusion, environmental and social justice (NCS document, 2003) is an important NCS principle, which implies that educators must encourage learners to explore societal issues in ways that relate to Physical Science. This can be achieved by applying what Aikenhead (1994) calls a Science- Technology – Society (STS) approach. Hence, STS may be defined as a way of reforming science instruction so that it makes sense to learners.

1.3. Rationale of the study

The study was informed by my frustration in 2007 when teaching chemical systems the previous year in grade 10. I realized that it was not easy to teach a new topic and to develop strategies that can help learners develop their skills, to assist them to become responsible

citizens. Integrating LO3 into our teaching was a challenging task as it required me to have sufficient knowledge of the role of science in the society (Davies and Toerien, 2008). Chemical systems is a new knowledge area so there is a limited range of teaching material that has been produced to help educators to understand the topic. Another reason which prompted me to do the study was that as educators we do not get enough assistance in implementing a new curriculum. Therefore, it becomes difficult to implement especially if the content knowledge is new. Work done by Scholtz, Watson and Amoson (2004) showed that teachers need support in adapting new ways of teaching, so that they can address the realities of the context of teaching. Another reason for engaging in this study is hopefully to contribute to the knowledge base of teaching denoted by Opie (2004), that one of the reasons for doing educational research is to come up with outcomes that could be shared and used by others, in that way educators may improve.

1.4. Statement of the problem

Progression is an important principle in NCS, because learners develop advanced, complex knowledge and skills as they move from one grade to the next. Based on my first experience of teaching "chemical systems" (which is a new knowledge area) in Physical Science, it was difficult to come up with strategies to enhance conceptual understanding and develop skills that would be used in the next grade. It was difficult to create opportunities that relate Physical Science to a broader social goal of promoting human rights, environmental justice and social goals. The reason could be that, the core concepts to be learned in chemical systems are geographic concepts of which I possess limited knowledge. Shulman (1986) addressed the question of how content knowledge and pedagogic knowledge are related. He emphasizes that a teacher must have knowledge of subject matter and the methods of imparting the knowledge to the learners so as to make it comprehensible. Hence, Halim and Meerah (2002) in their report suggested that the teachers' development of pedagogical content knowledge (PCK) is especially important to those who teach outside their expert areas. The study is important because it will make a substantial contribution to my knowledge, enabling me to gain insight into the concept of energy resources and improve my own teaching, as well as informing others of the kinds of challenges faced.

1.5. Aims of the research

The specific aim of this study is

- To carry out a self-study of how I transform my content knowledge when teaching energy resources and its uses to make it comprehensible to learners.
- To develop and produce a set of lesson plans which other educators can use.
- To improve my own practice.
-

1.6. Research Questions.

The purpose of the study will be to find out

- How did my PCK develop as I developed the broad content of the energy resources and its uses into focused, teachable and comprehensible content?
- How did my planning and reflecting on practice change as I participated in the process of planning, developing and implementing the lesson plans ?

1.7. Outline of the research report

Chapter one gives an overview of the study. This includes the introduction to the study, the rationale for the study, stating the aim, giving the statement for the study and stating the research questions.

Chapter two outlines the theoretical framework of the study and relevant literature is reviewed and discussed. In this chapter I have selectively reviewed literature about pedagogical content knowledge and literature related to effective teaching and learners difficulties with chemistry topics are considered.

Chapter three gives the description of the overall design of the study as well as the rationalization for data collection methods .

Chapter four gives a detailed description of how the PaP-eRs and the CoRes were developed. In this chapter the PaPeRs and CoRes are presented in detail, and a brief discussion how the PaPeRs were created is articulated. It further addresses how I designed and taught the lessons.

Chapter five. In this chapter the evolution of my PCK is outlined in detail and analysed. This chapter discusses how I articulate each element of PCK in my classroom in an effort to make it explicit.

Chapter six summarizes the findings of the study and concludes by giving critical reflections of the study. The limitations , recommendations of the study are highlighted and it ends with a brief recommendations for further study.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

This chapter focuses on the different views from the literature about PCK and the teaching of energy resources. Below, the first part of the chapter deals with how pedagogical content knowledge is perceived by various authors. Central to this study is literature on how concept maps shapes the content knowledge when teaching a new topic. Therefore the discussion that elaborates on how content knowledge develops as the teachers use concepts maps and the difficulties that are encountered when an educator is teaching new content will be given from various literature. Lastly, learner's difficulties in chemistry are discussed and the concluding remarks are given.

2. 2. Theoretical Framework

2.2.1. Pedagogical Content Knowledge

The concept of pedagogic content knowledge (PCK) was introduced by Shulman (1986) as a body of knowledge for understanding teaching and as the professional knowledge base for teaching. The domains of PCK which are fundamental components are a combination of subject matter and pedagogic knowledge. The teacher must critically reflect and transform the subject matter in order to represent the subject matter in a various way. Shulman (1986) outlined a theoretical framework describing teachers' special knowledge, which includes content knowledge, pedagogical content knowledge and curricular knowledge.

Content knowledge refers to the knowledge of the subject matter per se the knowledge the teacher has in his/her mind, which includes the understanding of the facts and structures of the subject matter (Shulman,1986b). This means that teachers must be in a position to convert their pure science content into science content for teaching. The concept of pedagogical content knowledge (PCK) where content and pedagogy are blended can enhance the transformation of subject matter knowledge. Furthermore, PCK is explained as

'The most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations, - in a word, the ways of representing and formulating the subject that makes it comprehensible to others'

(Shulman, 1986:p 9)

Shulman (1987) contend that teachers' PCK originates from their understanding of the content, their teaching practice and their own school experience. Shulman,1987 elaborate further in suggesting that possession of this knowledge on its own is not enough:

> *Since there are no single most powerful forms of representation, the teacher must have at hand a veritable armamentarium of alternative forms of representation some of which derive from research whereas others originate in the wisdom of practice.*
>
> (Wilson *et al.* 2004: p 203)

Then in his later paper (Shulman,1987) further refined his three categories of teachers knowledge to a comprehensive list as follows:

- Content knowledge
- General pedagogical knowledge,
- Curriculum knowledge
- Pedagogical content knowledge
- Knowledge of learners and characteristics
- Knowledge of educational context
- Knowledge of educational ends, purpose and values

Shulman (1987) argued that in PCK, content and pedagogy are mixed together. The teacher combines his/her understanding of the topic with instructional strategies and knowledge to enhance student's learning. According to Shulman (1987) teachers have the ability to reshape the knowledge, simplify and identify various representations for concepts to increase learners comprehension.

Various authors have elaborated on Shulman's work and have proposed different conceptualizations of PCK. Cochran, DeRuiter and King (1993) modified Shulman's concept of PCK based on a constructivist view of teaching and learning processes. They argue that

Shulman's view of PCK was based on objectivist and constructivist perspectives and both perspectives could not provide a distinction between content knowledge and PCK. Therefore, Cochran et al., (1993) developed the concept of PCK based on the constructivist perspective, hence refer to PCK as a pedagogical content knowing (PCKg). PCKg emphasized the importance of the teacher knowing about the environmental context in which learning and teaching occur and the knowing about the learning of their learners. Cochran *et al.,* (1993) proposed the following definition of PCKg:

> *"A teacher's integrated understanding of four components of pedagogy, subject matter knowledge, student characteristics, and the environmental context of learning".*
>
> (Cochran *et al.*, 1993: p265)

This definition implies that Shulman's idea was elaborated by including learner's abilities, attitudes, values, and prior knowledge as well as how they construct knowledge. According to them PCK refers to the ability of a teacher to transform content knowledge by considering learners' difficulties at any point in time and address factors which may hamper learning of scientific concepts. The other component included by Cochran *et al.,(*1993) was the environmental context of learning, which can affect the teaching and learning process. This includes teacher's understanding of social, political, cultural and physical environments. They further indicated that acquiring pedagogical content knowing is an ongoing process where this knowledge has a dynamic nature. Cochran *et al.,* (1993) uses the terms such as synthesis, integration and transformation to explain the changes occurring in PCKg.

Work done by Geddis and Wood (1997) suggests that they conceptualize PCK as the transformation of subject matter into forms that are accessible for learners. According to them the domains of PCK are constrained by the nature of the subject matter itself. Therefore, PCK involves using a continuous strategy, which guards against misinterpreting the subject matter. Furthermore, they elaborated that experienced teachers know the problems and difficulties learners have with regard to frequently taught topics and they are able to come up with a remediation strategy in case of an unforeseen situation (Geddis, Onslow, Beynon and Oesch, 1993). Their categories of PCK which were adapted from Shulman (1987) were learner's

prior concepts, subject matter representation, instructional strategies, curriculum materials and curricular saliency.

Van Driel, Verloop and de Vos (1998) referred to PCK as a 'specific form of craft knowledge'. Craft knowledge was defined as

> "*an integrated knowledge that represents teachers accumulated wisdom with respect to their teaching practice*" (Van Driel *et al.,* 1998: p 678).

According to them this special knowledge allows the alteration of subject matter, so that it can be applied effectively during the process of teaching and learning. They further elaborated that PCK may develop from teacher's own practice and from schooling activities.

Magnusson, Krajcik, and Borko (1999) identified the process of construction of PCK as a transformation process of several forms of knowledge for teaching. Magnusson *et al.,* (1999) established that PCK consists of five components which were orientations towards science teaching, knowledge of curriculum, knowledge of science assessment, knowledge of science learners and knowledge of instructional strategies. It is evident that most authors agree that the development of PCK is an ongoing process rooted in classroom practice (Van Driel , De Jong and Verloop, 2002).

Bishop and Denley (2007) proposed their own metaphor that shows the relationship between PCK and other knowledge base elements proposed by Shulman (1987). They elaborated that professional knowledge can be compared to a spinning top with coloured segments (the knowledge categories) see figure 2.1. PCK is the blending of colours to form a white, which is different from the colours it constitute (Bishop and Denley, 2007). According to them the combination of the knowledge base elements forms PCK. The knowledge categories are as follows;

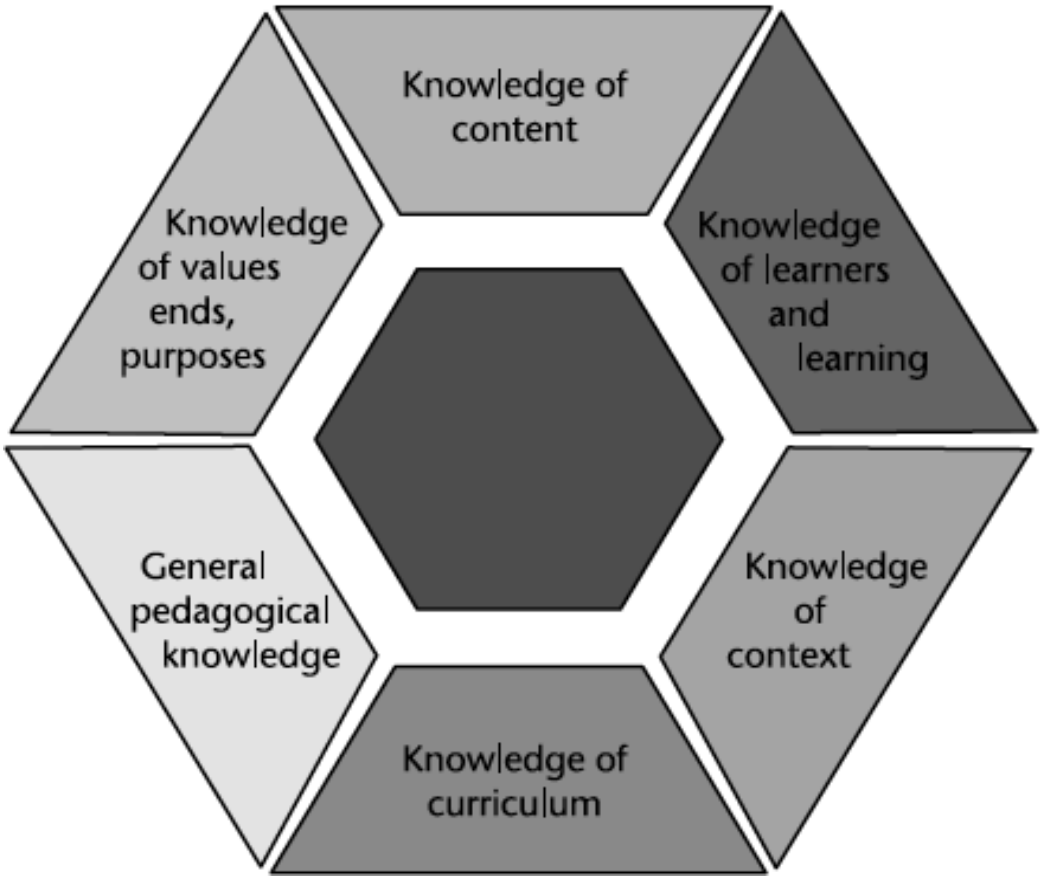


Figure 2.1: *The 'spinning top'- Metaphor for professional knowledge (Denley and Bishop 2007)*

In 2008**,** Rollnick, Bennett, Rhemtula, Dharsey & Ndlovu used the domains which Cochran *et al.*, (1993) regarded as teacher's knowledge domains. The teacher knowledge domains consist of four fundamental domains namely: subject matter, knowledge of students, general pedagogic knowledge and knowledge of context. Rollnick *et al.*, (2008) contend that the domains combine to produce PCK which is manifested in various forms in the classroom. The manifestations may include any visible products like subject matter representations, topic specific instructional strategies, curriculum saliency and assessment of teaching. The visible product is what the teacher does in class during teaching.

In the present study I have considered PCK as knowledge that plays a role in transforming subject matter into forms that are more accessible to students. Hence I have adopted Geddis

and Wood's (1997) model adapted from Shulman's components of PCK to look at how elements of my PCK were transformed during my own practices. However, for this study some modification of the PCK components will be done because I believe that 'knowledge is actively created by the knower and not passively received in an unmodified form from the environment' (Cochran *et al.*, 1993). The model I have used is shown in figure 2.2 below

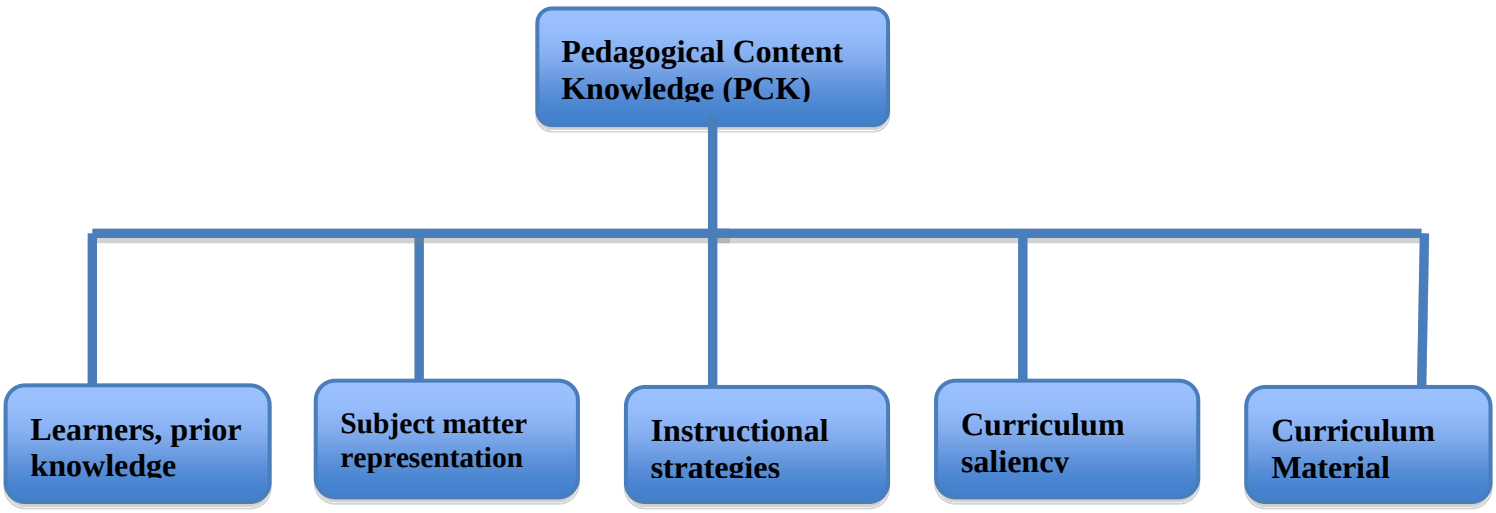


Figure 2.2: *Teacher's knowledge that facilitate transformation of subject matter (Geddis and Wood, 1997).*

The sub categories according to Geddis and Wood (1997) will now be further elucidated

- **Learner's prior knowledge** -Learner's prior knowledge means their knowledge related to the concept to be taught, the alternative conceptions they have about the concept and the difficulties they have about that concept. According to Cochran *et al.*, (1993) learner's prior knowledge is important because learners do not come to class as empty slates as indicated by Piaget(1977) but they have their own conception about the topic to be taught. Work done by Lee and Luft (2008) has shown that understanding learner's prior knowledge, needs, interest, learning difficulties and misconceptions held by learners is essential in making decisions concerning the curriculum organization and teaching strategies. Therefore, if educators know the misconceptions learners have, they can make a decision on how to organize the

content knowledge to be taught. Furthermore, teachers need to know how students learn the material for example, whether they have ability for independent learning.

- **Subject matter representations-** refers to the forms of representation that can be shown by the use of most powerful analogies, illustrations, examples, explanations, simulations and demonstrations (Shulman 1986). The analogies used in a classroom setting provide one with picture of the educator's knowledge structure regarding the specific content. Child and McNicholl (2007) argue that the reason that makes educators to use analogies is to make scientific ideas accessible to learners. However, when teaching outside your comfort zone or a new topic it becomes difficult to come up with a representation that will enhance learning.

- **Instructional strategies-** refers to different approaches that teachers use like whole class teaching, problem solving strategy, group work, question and answer strategy. Geddis and Wood (1997) contends that instructional strategies are essential approaches that focus on the purpose for teaching a particular topic and simultaneously address misconceptions that teachers find in their learners' prior knowledge.

- **Curriculum Material –** According to Geddis and Wood (1997) this refers to the necessary material and resources for representing the subject matter and for utilizing particular teaching strategies. These may include a variety of materials such as worksheets, transparencies, chemicals, laboratory apparatus, and books among other materials.

- **Curriculum Saliency-** refers to the breadth and depth of syllabus coverage, which includes content not to be taught at that particular time due to pedagogic reasoning. According to Geddis and Wood (1997), it refers to the teacher's understanding of the place of a topic in the curriculum. This teacher's manifestation may be observed in the teacher's awareness of how the topic they are teaching fits in with other topics and part of the curriculum past and present. In most cases what is most likely to be in the learner's examination influence the curriculum saliency.

The reason why I chose Geddis & Wood's (1997) model of PCK is because they extend the explanation of Shulman's PCK as a transformation of subject matter, which is needed to be used effectively during the classroom practice. Their model draws some of its components from Cochran *et al.*, 1993).

2.2.2. Capturing and Potraying PCK

Loughran, Berry, and Muhall (2004) used another approach to capture and portray the development of PCK. They developed an analysis scheme using two complementary tools called Content Representation (CoRe) and Pedagogical and Professional – experience Repertoires (PaP-eRs). The first element, the CoRe is an overview of how to conceptualize the teaching of content of a particular topic. According to Loughran *et al.*,(2004) the CoRe is developed by asking teachers to think about 'BIG IDEAS' related to the particular topic to be taught based on their experience. Then for each Big Idea teachers respond to a series of prompts (see below)

- **Prompt 1**: *What you intend students to learn about this idea*
- **Prompt 2:** *Why is it important for students to know this*
- **Prompt 3**: *What else you might know about this idea (that you would not share with students yet)*
- **Prompt 4:** *Difficulties/ limitations associated with teaching this idea*
- **Prompt 5:** *Knowledge about students thinking that influences my teaching of this idea*
- **Prompt 6**: *Other factors that influence my teaching of this idea*
- **Prompt 7:** *Teaching procedure (and particular reasons for using these to engage with this idea)*
- **Prompt 8:** *Specific ways of ascertaining students understanding or confusion around this idea*

Loughran *et.al* 2004 found that the use of a CoRe was invaluable in extracting knowledge from experienced teachers. This include justifications and how the concepts might be taught, how and why (Loughran *et al.*, 2004).

The second element, the PaP-eR brings life to the aspects of PCK, it focuses on pedagogic decisions made by an educator when teaching. This may come from comments made by the teacher during interviews, teaching journals, lesson plans, teacher analysis of learners' work and observer's voice (Loughran, Berry & Mulhall 2004). In the present study a modified CoRe and PaP-eR was used to capture and portray my PCK when teaching a new topic. Unlike Loughran *et al.,* (2004) they were not developed using a group of teachers but developed in stages using data collected during teaching, using data collected during the lesson preparations and data collected during meetings with the collaborative group. The focus of this study, then, is on how, by using PCK as a conceptual framework (Loughran, Mulhall and Berry, 2008) I arrange subject matter and learn to teach new content knowledge in a way that would be better understood by students.

2.2.3. The Profile of Implementation

Profile of implementation is one of the three constructs developed by Rogan and Grayson (2003) as a theory on curriculum implementation. This theory draws on school development, educational change and science education literature. The other two constructs, which shape the theory are "capacity to innovate" and "outside support". Figure 2.3 below shows how the three constructs are integrated.

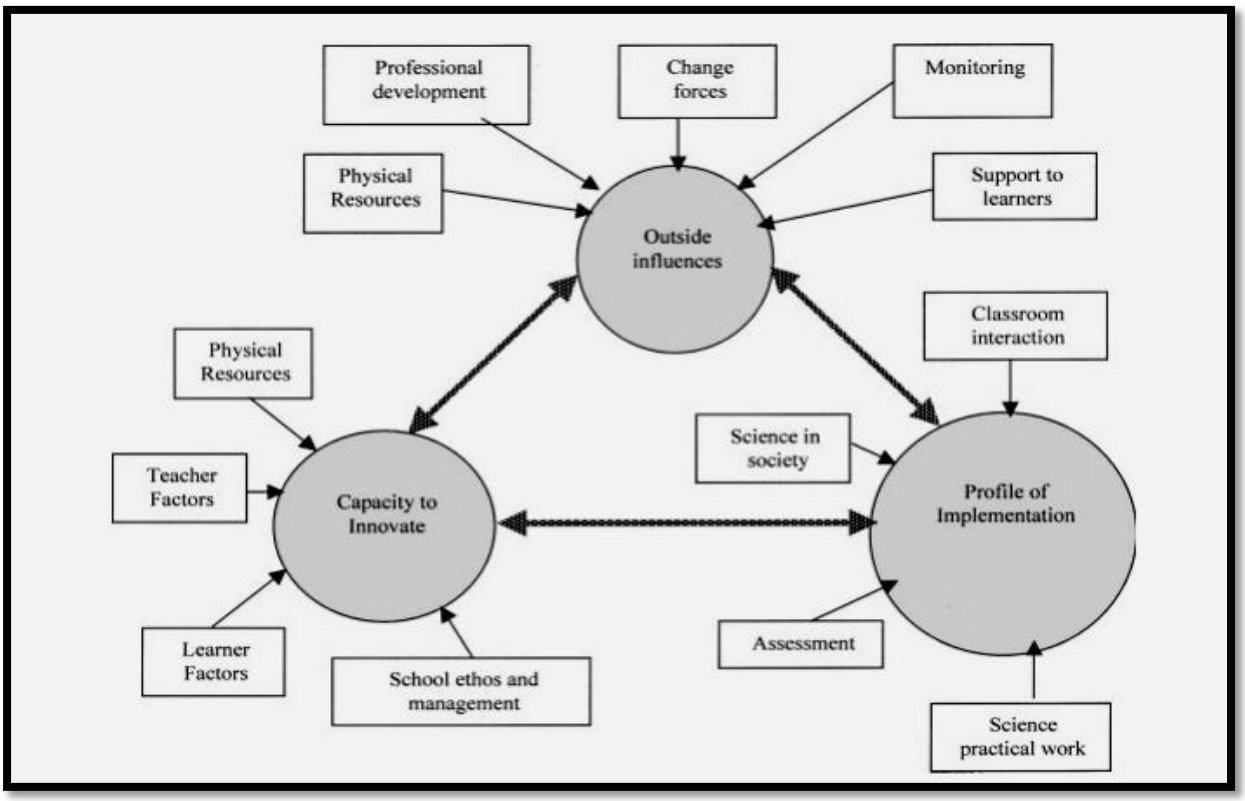


Figure 2.3: *The model derived from Rogan and Grayson (2003) as shown in Rogan and Aldous p314 (Rogan & Aldous, 2005)*

The study's central point is the profile of implementation which will help as a guide on which I can identify where I am currently and select a route to follow in working towards a meaningful implementation (Rogan, 2004). According to Rogan and Grayson (2003) the construct profile of implementation is the extent to which the ideals of a set curriculum proposal are being put into practice. It allows one to identify the extent to which the new curriculum is practice in class. This construct has four dimensions, which are classroom interaction, science in society, assessment and science practical work.

The dimension "science in society" reflects one of the requirements of NCS. The four dimensions work on progress measured in four levels. Level one demonstrates a model of a teacher- centred approach to level four which is open–ended learner centred approach which is more in line with the new approach of the curriculum. The fourth level of progress includes the lower level, so it is cumulative rather than a progression from one level to the other (Rogan & Grayson, 2003). The levels imply the increasing mastery of teaching and learning strategies. Though, it is important to note that the three constructs are interdependent for effective implementation of a new curriculum.

In this present study, to understand better my ability to implement the curriculum I will only report on the degree to which on two sub-construct of the profile of implementation was achieved , that is science in the society and classroom interaction. As alluded above each sub-construct can be realized at varying levels. Shown below are the four levels of science in society and classroom interaction.

Table 2.1: *Description of four level at which "profile of implementation i.e. Science in Society" might be realized.*

Levels	Science in society	Classroom interaction
1	Teacher uses examples and applications from everyday life to illustrate scientific concepts Learners ask questions about science in the context of everyday life	Present content in a well organised ,correct and well sequenced manner, based on a well designed lesson plan. Provides adequate notes. Uses textbook effectively. Engages learners with questions. Learners stays attentively, and engaged. Respond to and initiate questions
2	Teacher bases a lesson on a specific problem faced by local community. He/she assist learners to explore the explanation of scientific phenomena by different cultural groups	Teacher uses textbook along with other resources. Engages learners with questions that encourage in depth thinking Learners use additional sources of information to compile notes
3	Learners actively investigate the application of science and technology in their own environment, mainly by means of data gathering methods such as surveys. Example here might include an audit of energy use or career opportunities that require a scientific background.	Teacher probes prior knowledge. Structures learning activities along good practices lines. Introduces learners to the evolving nature of scientific knowledge. Learners engage in minds on-learning activities. Make own notes on the concepts learned from doing these activities.
4	Learners actively undertake a project in their local community in which they apply science to tackle a specific need. Learners explore the long term effects of a community project. For example a project may have a short term benefit with a long term detrimental effects.	Teacher facilitates learners as they design and undertake long term investigation and projects. Assist learners to weigh up the merits of different theories that attempts to explain the same phenomena. Learners take major responsibility for their own learning, partake in the planning and assessment of their own learning. Undertake long term and community based investigation project .

2.3. Background on mining

Mining is a new topic in the South African NCS Curriculum (DoE, 2003). It is part of a knowledge area 'chemical systems' in grade 11.This knowledge area involves STS approach of teaching.

2.3.1. Context based approach

Bennett, Lubben & Hogarth (2006) define context-based approach as the approach that uses contexts and applications of science as the starting point in order to develop scientific ideas.
An STS or context based approach is a way of reforming science instruction so that it makes sense to learners (Aikenhead, 1994) and encourages learners to look at the science around them and try to understand it from a societal point of view rather than from the scientist point of view (Holbrook, 1992). This approach is included in the present study mainly because an energy resource integrates science, technology and society. Also because it relates very well to learning outcome (LO3) that emphasizes the idea that learners should have a broader understanding of how the science learnt in school relates to their everyday lives, to their environment and to a sustainable future (DoE, 2003). Teaching science the STS way means learners are encouraged to explore societal issues in ways that relate to science. According to Bennet & Lubben (2006) learners who are taught using the context-based approach develop scientific ideas to a greater extent and understand scientific concepts better.

Yager (1992) indicated that STS puts application first and scientific knowledge is sought to give learners an in- depth view of science. Yager (1992) further indicates that the approach allows learners to experience concrete activities and are given opportunity to verbalize their understanding by being engaged in group discussions. Therefore STS employs a constructivist approach. Constructivists ascertain that teaching is done better if learners' prior knowledge is identified (Matthew, 1995). Teaching needs to interact with these ideas, by encouraging learners to declare what they know and then promote consideration of whether other ideas make better sense.

2.4. Learner's difficulties in chemistry topics and effective science teaching.

For effective science teaching the constructivist approach to learning is important, it has three fundamental aspects; multiple forms of knowledge, the role of prior knowledge and the social

nature of knowledge and its acquisition (Hausfather, 2001). The role of prior knowledge is essential for effective teaching, it includes both teachers' and learners' prior knowledge. A study conducted done by Halim and Meerah (2002) with Malaysian science teachers, has shown that good representation of specific topic is a product of previous planning, teaching, and reflecting. Therefore, for educators to teach effectively they must consider their prior planning and reflect on their previous lessons.

Being aware of learner's ideas in chemistry can provide a useful guideline for the nature and sequencing when introducing new and abstract concepts. For effective science teaching the educator must have sufficient content knowledge and knowledge of student's conceptions /misconceptions so as to shape his teaching. Insufficient content knowledge leads to difficulties in becoming aware and addressing learner's misconceptions (Halim, and Meerah, 2002). Work done by Borrower (1991) in Halim and Meerah (2002) showed that 20 Canadian high school teachers could not detect learner's misconceptions prior to instruction because of lack of content knowledge.

A survey done by Chiu (2005) in Taiwan, suggested that possible causes of misconception for learners included poor language skills due to the difficult chemistry language, poor background knowledge of chemistry and students had varied backgrounds of scientific concepts.

2.5. Chapter summary.

The literature has been reviewed and theoretical framework discussed, which sets basis for the next chapter. The following chapter will deal with research methodology and how data was collected.

CHAPTER 3
RESEARCH DESIGN AND METHODOLOGY

3.1. Introduction

This chapter outlines the research design, methodology employed in this study. Instruments used to collect data and how I used them will be outlined later. Finally, the issue of ethics, validity and reliability will be discussed.

3.2. Research design

The aim of the study was to track the development of my pedagogical content knowledge in natural settings; therefore it lends itself to a qualitative study. According to White (2003), qualitative research assumes multiple constructions of realities, a study of an ongoing process in natural settings and takes subjectivity into account in data analysis and interpretation. A case study was appropriate for this study because it involves a detailed study of the practice of one educator (myself) in one school when teaching a new topic. Hitchcock and Hughes (1989, cited in Opie 2004) further state that case studies involve a tight focus on a particular instance with the intention of uncovering ways in which events converge to create certain outcomes.

The advantage of using case study research is that it allows features of experience, which are shared by many people to be studied in detail and depth. However, Guba and Lincoln (1983) indicated that results from a case study cannot be generalized as data collected is not from a sample.

3.3. Methodology

The primary aim of doing the study was to use it as a practical tool to solve the problems I had with implementation of topics in the new curriculum. I reflected on my practice, designed a change that addressed the problem and implemented the change (Hatch, 2002). So the research approach that was appropriate for my study was self- study research. The methodologies implied by action research and self-study are linked to each other. Both methodologies involve teacher's enquiry using research methods to study classroom problems (Macmillan *et al.,* 1993). According to White (2003) action research is 'a form of

self-reflective enquiry undertaken by participants in social (including educational) situations in order to improve the rationality and justice of their own social or educational practices and the situations in which these practices are carried out. The selected writers have an influence on my understanding of self-study. Therefore, I view self- study as inquiry done by teachers researching their own practice (in classroom) in order to improve my practice.

The reason I chose a self- study approach was that gave one an opportunity to learn from inside. According to Bullough and Pinnegar (2001), "self study should promote insight and interpretation'. Therefore learning from inside offers an opportunity to gain insights in the practice, which is more difficult to gain from an outside perspective. Hence doing research from the inside will enhance my knowledge for teaching and learning. Loughran (2007) argues that when self-study is explored genuinely new insight into teaching and learning is gained if the practitioner practices modelling. Therefore I hoped to grow professionally. However, as a researcher from inside it becomes difficult to interrogate yourself and include aspects of experiences that are personal and cannot be observed by others. Hence it is important to acknowledge that the study does not focus on you but on the gap between you and the practice involved (Bullough and Pinnegar, 2001). As a result, self- study raises the issue of bias and results cannot be generalized.

Well-conducted self-study can lead to own personal development, better professional practice, developing a model of critical reflection and generating more meaningful alternatives to professional evaluation (Loughran, 2007). Through self- study, insight on chemical systems would be gained, because I will reflect on my current practice, identify problematic aspects and solving them systematically. Strategies used during the study, which helps learners comprehend the content will be shared with colleagues and they can use them to inform their teaching. However, one must acknowledge that the strategies might not work with another teacher because the condition or environment where the teaching takes place might not be the same.

3.4. Sample

The study explores how my pedagogic practices changed in response to curriculum implementation especially when teaching the section of energy resources and their uses. The sample consists of one educator teaching in a township school (myself), who has an honours degree and is a qualified Physical Science teacher. I have many years of experience and I was subject specialist in the school. The socio-economic background of the community is so low such that most learners belong to families where no one is employed. This situation has negative effects on the school as crime and burglary in the school has increased, leaving the school poorly resourced. All learners in the school are African; come from different ethnic groups and their primary languages are seSotho, IsiZulu, and IsiXhosa. Though the medium of instruction is English, learners are not comfortable speaking it because it is their second language.

3.5. Methods.

Data were collected in a form of lesson video recording, document study such as learners' worksheets; concept maps, reflective journal, lesson plans and reference group discussion. Below is an explanation of each on how each was used.

3.5.1. Lesson video recording

Video recording used as a means of gathering information about teaching, allows the observer to observe many aspect of teaching and provides heuristic and accurate information (Opie, 2004). The advantage of videotaping is that it can be re-analysed later and information can be kept to be used later. Opie (2004) argues that video recording allows the study of verbal and non- verbal human behaviour during the teaching of a lesson. Lesson videotaping makes it possible for the researcher to determine people's perceptions of events and processes expressed in their actions and expressed as feelings, thoughts and beliefs (Macmillan & Schumacher, 2006). The disadvantage of using video- taping as supported by Opie (2004: 122) is that people consciously or unconsciously, may change the way they behave when being observed. This was addressed by videotaping all lessons so as to get the subjects familiar with the situation of being video-recorded. Observation helps to identify any teaching strategy employed during the presentation of the lesson, which cannot be possible

when using other methods. Opie (2004) also indicates that information about the physical environment and about human behaviour can be recorded directly.

In this study, four consecutive lessons for each class were video recorded. Each lesson was 60 minutes long and the recording was done by a learner who was a novice recorder. Observation is not objective, it can be difficult to analyze the data captured especially if the person recording is not a professionally and no briefing done before the lesson. Since my concentration was on capturing everything that is happening in the classroom, I also used audio recording to capture the details of the voices of the participants.

Video and audio recordings are good methods of collecting data because they can be viewed repeatedly allowing variety of analyses. The other advantage of using video recording is that behavioural patterns of the teacher and learners can be seen and this instrument helps to get comment from other teachers who were present at the time (Hopkins 2008). The limitation of this instrument is that the presence of the video equipment, which was be used to record data; may have some effects on the behaviour of the subjects and shows isolated situations (Hopkins 2008). To address that concern data were collected over a few days. The use of video recording as a source of data in observation helped in identifying behaviour, which cannot be seen in a questionnaire. Subjects were asked to elaborate on various activities observed during classroom observations.

3.5.2. Learner's worksheets

Learners' worksheet were another form of data collected. Learners were given an activity after teaching the first lesson (see Appendix C).This activity was in a form of worksheet, it consolidated the learners understanding of how coal is formed. Their worksheets were photocopied and kept for analysis before being returned to them. This was done to capture learners' understanding of the content. A sample of the learner's worksheet is included in Appendix E.

3.5.3. Collaboration team

According to Macmillan and Schumacher (2006) a collaboration team is one of the strategies to enhance reflexivity. Elijah (2007) argues that collaboration in self-study augments

learning, understanding and supports alternative explanations. The collaboration team helps with clarifications because when an individual is reflecting on her own, ideas are limited. The collaboration team supports and validates information to the participants. Samaras and Freese (2006) explained that self- study must not be done in isolation, it needs collaboration for building new understandings through dialogue and validation of findings.

The collaboration team comprised of my co- supervisor a PhD student, a fellow masters students who is also Physical science educator, me and my supervisor an expert in chemistry education. The physical science educator was also doing a self-study but on learning and teaching of gold mining. A pseudonym name (Mrs Moloi) was used for the Physical science educator. The team met for the first time after I had constructed my first concept map, they encouraged us to read and understand the content knowledge about coal and gold mining in preparation for the development of the CoRe. We were also advised to think and come up with Big Ideas to discuss them in our next meeting. We met regularly during the data collection, write up discussions and reflection. To capture our discussions we used voice recording instruments such as cell phones and scribble some notes to remind ourselves on what was discussed.

The group helped me in the writing of my journal, gave me support when developing lessons and gave me insight on the content knowledge that was difficult to understand. They helped us with the technicalities of the research such as collecting the data, analysing the data and how to document a journal. I was in position to document my thinking for example when creating concepts maps, personal reflections, comments on my thoughts and things I changed during the teaching.

3.5.4. Concept maps

Concept maps as defined by Novak and Canas (2008) are "graphical tools for organizing and representing knowledge, they include concepts, usually enclosed in circles or boxes of some type, and relationships between concepts indicated by a connecting line linking two concepts". Since the investigation was a self –study intending to capture the growth of content knowledge when teaching a new topic, using concept maps was appropriate. Novak and Canas (2008) argues that, concept map not only allowed us to represent knowledge, but

also to find gaps in the knowledge structure. I constructed two concept maps. The first concept map was constructed based on what I knew before learning any material on energy resources and before meeting with the collaborative team. Therefore, it showed my prior knowledge and misconceptions I had about the topic and there is no progression from grade ten to grade twelve.

The first concept map was exposed to the collaboration team for comments and input. Then, the second concept map was developed after teaching the first group, this concept map was influenced by the comments and inputs made during our collaboration meeting. My reflective journal also played an important role when constructing the concept map. Novak and Canas (2008) argues that to summarize the understandings obtained by learners' after they have studied a unit, concept maps are a relevant tool to use.

3.5.5. CoRe's , PaP-eRS and Lesson plans

CoRes and PaP-eRs (Loughran *et al.,* 2004) were used to capture the way of representing my understanding of the different aspects I consider when preparing and presenting a lesson in a particular topic. The CoRes and PaP-eRS are explained in detailed in chapter 2. The CoRes used in this study were prepared with help of Mrs Moloi who, as stated above, was doing a self -study on teaching Gold Mining. The development of the CoRe was done in three stages. The first stage (CoRe 1) was before preparing the lessons and before learning much about energy resources. Therefore it also captures our understanding of the topic and our misconceptions were also revealed. After the development of the first CoRe it was then exposed to the collaboration team for discussion. The second CoRe (CoRe 2) was then developed after the refinement of the first CoRe and it was then used to prepare our first set of lesson plans, which were to teach the first group. Then the lesson were then presented to peers, who assisted me to modify them while I reflect on them. The last stage of the CoRe (CoRe 3)was done after meeting with the collaboration team, teaching the first group and using my reflective journal.

PaP-eRs as described by Loughran (2007) ' are designed purposefully to impact a teacher's thinking about a particular aspect of PCK in that given content and so largely based around

classroom practice'. The PaP-eR's in this study demonstrate how PCK is evident in bringing life to specific aspects of the CoRe. Therefore the PaPeRs reflected aspects of my teaching.

Lesson plans (see appendix C) were another source of data, as my intention was to capture which strategy helps learners to understand the content better. I had to adapt the lesson plan for the second group of grade 11's, because of the reflections and comments from the collaboration team.

3.6. Data collection process

As part of the self -study, I taught two Grade 11 classes consecutively for two weeks and the classes involved in the study were my normal classes. Below is a flow diagram showing the sequence of how the data collection process took place. In the process below the purple highlighted blocks indicate the meeting with collaboration team, and orange highlighted one indicate the individual activities.

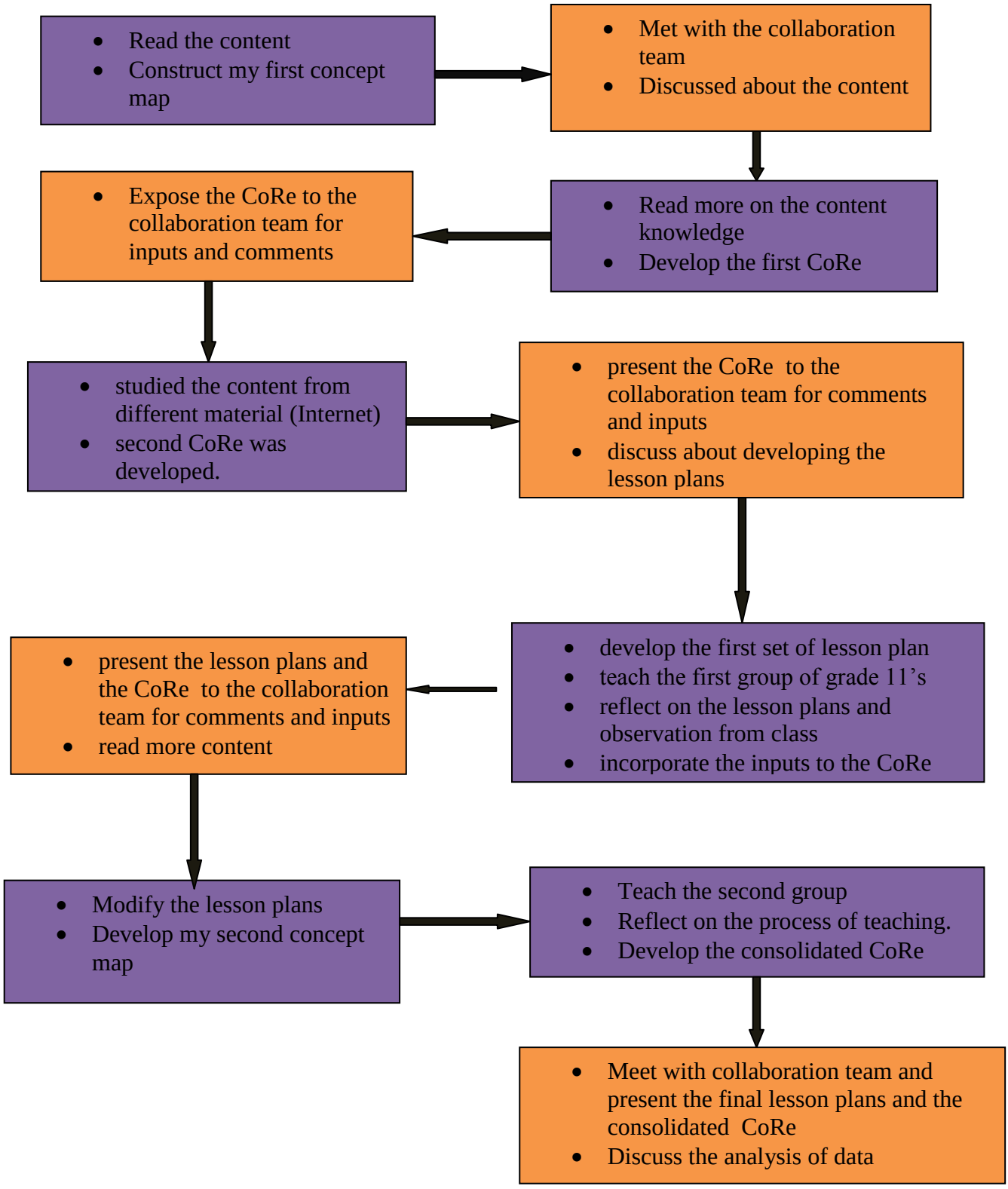


Figure 3.1: *Flow diagram (Data collection Process)*

As part of data collection process, we were working with the collaboration team, I first constructed my first concept map (figure 5.2 in chapter 5) and develop our first CoRe before

learning much about the content knowledge. The CoRe was then exposed to the collaboration team for modification and comments. I then studied the content from different material including material on the Internet, and then the second CoRe was developed. The second CoRe was also presented to the collaboration team for comments and inputs. After refining and incorporating the inputs, I then develop the first set of lesson plan to be used for teaching.

The four lessons were delivered to the grade 11's and they were video recorded. It must be noted that the lessons were taught in different weeks for both classes, the first group was taught using the first set of lesson plans and the last group was taught with the modified lesson plans after meeting with the collaboration team several times. Learners were given activities during the lessons using material from lesson plans to capture their understanding. After the presentation of my first set of lesson plans I then developed my second concepts map (figure 5.3 chapter 5) which integrated inputs from the collaboration team and knowledge gained from reading more content on energy resources. Shortly, after teaching the last group the final CoRe was developed and the final version of the lesson plans (appendix C) were then developed and scrutinized by the subject experts.

3.7. Data analysis.

Analysis of the data from the transcripts of selected sections of the audiotapes, video recording, concept maps and student's worksheets were analysed using a framework adapted from Geddis and Wood (1997). The framework was modified to suit my study. The research questions served as a guide for conducting analysis. Relevant literature was used to suggest initial categories for coding the data. Given that qualitative research is open-ended and an ongoing process, therefore a grounded theory will also be used as an analytical tool. For this study the framework by Geddis and Wood (1997) was suitable, therefore modification were done where possible. According to Macmillan and Schumacher (2006) through the use of inductive analysis, categories and patterns emerge from the data.

3.8. Ethics considerations

'Ethics has to do with the application of moral principles to prevent harming or wronging others, to promote the good, to be respectful and to be fair' (Opie 2004,p122). Ethical issues

arise throughout the research process, in research design, access, procedure of data collection, interpretation, analysis and writing up. Hence below, a discussion on how ethical issues were addressed in my study are elaborated. The guidelines as described by the University of the Witwatersrand, Johannesburg, ethics committee were used to guide the study (Appendix B). The study was a self-study that aimed at improving my own practice, so applying for permission to use the school and learners from the Department of Education was important. Letters sent to the learners' parents, the school principal were written and verified by the supervisor. This was to ensure that they contained adequate information for the possible respondents about the research. The letters were seeking permission and outlining the intentions of the research (appendix A). The contents of the letter were, the aims of the study, a detail description on how and when the investigation was done and that no time was lost during the study.

The aim and purpose of the study were verbally explained to the learners when they were first approached. Learners were advised that the information collected would be used for improving my practice and to fulfil my educational requirements. After the comments from the supervisor the research proposal also containing letters was sent to the University of the Witwatersrand ethics committee. Permission from the ethics committee was granted to conduct the study (Appendix B). A research request form was also filled and submitted to the Gauteng Department of Education documents (appendix F).

The aim and purpose of the study to was investigate conceptual understanding indirectly from students' assignments and answers to questions during the lesson. Learners were assured that their contribution would only assist the researcher – teacher in improving her practice. I reassured the principal and the parents that no time would be wasted for syllabus completion since data was collected during presentation of lessons and the method used for collecting data in class was observation. All information would be treated with confidentiality and information that would harm or embarrass the learners or the teacher would not be revealed. The learners who actively participated in class during the lesson would have the opportunity to verify their statements when transcripts have been done in an attempt to identify or remove misconceptions. Learners' were reassured that once data had been collected, no one would have access to it except the research team. However, because of time

constraints, I did not have time of taking back all the transcripts and the video clips for verification.

3.9. Validity, Reliability and Credibility

The study employed qualitative research method; hence the methods I have used are subjective and grounded in practice. I regard validity as the 'the degree to which the interpretations and concepts have mutual meanings between the participants and the researcher' (White, 2003). To ensure validity, I used multiple methods to collect data to validate my findings and check with the learners the accuracy in their statement. However, I must acknowledge that I did not get a chance to verify all the transcripts. Rigour in research was judged by the way the research was planned, conducted, how results were recorded and the findings were interpreted and publicized. The research tools to be used in my research measured what the teacher and learners were saying, teacher's behaviour and interpret students understanding. Therefore, the study is subjected to descriptive validity, interpretive validity and internal validity.

Descriptive validity refers to the extent to which the activities seen as physical and behavioural events are described (Maxwell, 1992). To address the issue of descriptive validity I used a video camera to show the behaviour and listen to what was said. And triangulate the data, using my recorded perceptions in the reflective journal and written responses by learners in class. Interpretive validity refers to the degree to which inferences from the words and actions of participants in the situations studied are accounted by the participants (Maxwell, 1992). To enhance validity in this study data collected was exposed to the collaboration team for validation. The validity was ensured by getting comments from subject experts. I incorporated theses comments when developing the concept maps and in the process improved my content knowledge.

Schumacher & Macmillan (1993), regarded reliability as the extent to which a test or procedures similar results under constant conditions on all occasions. I prefer to regard reliability as property of the whole process of data gathering rather than a property of solely of results Opie (2004). Opie's (2004) definition is appropriate for my study, because conditions in a classroom situation might change for another researcher, then it would mean

the instrument is not reliable. Triangulate the data for example: What do I observe? What do students say? What do I see in student work? Addressing the issue of bias, I needed to develop disciplined methods to collect data that use self as a tool to construct insight. Samaras and Freese (2006) explained that self- study must not be done in isolation, it needs collaboration for building new understandings through dialogue and validation of findings. Hence, the video recording was exposed to the collaboration team for verification. The time was limited it was difficult to formulate a method of work which was sufficiently economical as regards to the amount of data collected and analyzing the data.

Credibility refers to the extent, in which results are judged to be trustworthy and reliable. Negative instances, such as – I had to empower myself so as to understand the subject matter better and include data that does not fit with my beliefs. The statements I made were acceptable, subjective and acceptable to make critical judgments. In the process of undertaking the research I repeatedly look for discrepant evidence to construct a credible report. Addressing the issue of bias, I developed a disciplined methods to collect data that use self as a tool to construct insight. Due to limited time it was difficult to formulate a method of work, which was sufficiently economical as regards to the amount of data collected and analyzing the data.

3.10. Chapter summary

This chapter described the research design and methodology employed in this study. It further gave the instruments used to collect the data and the their limitation. Lastly the data collection process was discussed and the rigor of the study outlined. The PaP-eRs and CoRes, which were used to capture, and portray PCK will be presented and discussed in the next chapter. In addition the construction of PaP-eRs and CoRes, will be outlined and the development of each BIG IDEA will discussed in detail.

CHAPTER 4:
CAPTURING AND POTRAYING PCK

4.1.Introduction

This chapter focuses on capturing and portraying my PCK. I have used research tools developed by Loughran *et al.,* (2004), viz. CoRe's (content representation) and PaP-eRs (Pedagogical and Professional-experience Repertoires) which complement each other.
Loughran *et al.*, (2004) developed and used CoRe and PaP-eRs to represent science teachers PCK about a particular topic. As explained in chapter 2, a CoRe focuses on capturing the teacher's knowledge, the teacher understanding of the aspects that shape the content to be taught and PaP-eR's brings life to the ideas in the CoRe, they are a narrative description of a teacher's PCK, it is a way of capturing what is happening in classroom and what influences the teaching and learning. Therefore, for this study the tools are used to capture and portray my PCK when teaching energy resources.

4.2.Development of CoRe

The CoRe and PaP-eR's in this study are used as tools to capture, portray PCK and assist in analysing the data. It articulates the various aspects a teacher considers when preparing to teach, presenting the lesson for a particular topic. According to Loughran *et al.* (2006)

> *'A CoRe (Content Representation) provides an overview of how teachers approach the teaching of the whole topic and the reasons for that approach - what content is taught and how and why - in the form of propositions. Importantly, a CoRe refers to the teaching of a particular topic to a particular group of students' (2006: p 21).*

A CoRe consists of a grid with 'big ideas' (Loughran *et al.*, (2004, 2006) heading the columns. Big ideas are the important science ideas a teacher regards as significant for understanding that particular topic (Loughran *et al*, 2004). Included in a CoRe are rows that consist of the prompts which are questions to be answered for each big idea. The prompt questions are:

- **Prompt 1:***What do you intend the students to learn about this idea?*
  In this prompt I must articulate what learners should be able to learn.
- **Prompt 2**:*Why is it important for students to know this?*

It is important to have sound subject matter in order to make a sound decision on what and why to teach. This is done by knowing what is relevant to science content and relevant to everyday lives of learners.

- **Prompt 3:**What *else do you know about this idea (that you don't intend students to know yet)?*
- **Prompt 4:***Difficulties/limitations connected with teaching this idea.*
- **Prompt 5:** *Knowledge about student thinking that influences your teaching of this idea.*

  This prompt is useful when planning for a lesson. It acts as a guide on what learners know and what are the possible misconception on this idea. Teachers draw on their knowledge about alternative conceptions that are held by learners about the topic when planning their lessons
- **Prompt 6:***Other factors that influence your teaching of this idea.*

  I will be indicating the general pedagogic knowledge in this prompt.
- **Prompt 7:***Teaching procedures.*

  The purpose of teaching procedures is to influence learners‟ thinking in ways that promote better understanding of science ideas.
- **Prompt 8:***Ways of ascertaining students' understanding?*

  Methods of establishing whether learners understood the content will be discussed in this prompt.

The CoRe in this study was developed in three stages. Mrs Moloi and I developed the CoRe, during the research process, moving from an initial CoRe, with many gaps to a final consolidated CoRe. During the initial stage of the development of the Big Ideas, we came up with sentences that has the following concepts in them "mining", "fossils fuels" and "environment impact". It was not clear to us yet what the big ideas were, we thought Big Ideas were sentences that you can easily pick and use from the textbook. The following is an extract taken from discussion we had with the collaboration team.

> **Chemistry Education expert** *' Big Ideas are seen as heart of understanding the topic you must teach, it gives a reason how a teacher approach a certain topic, they are not just sentences"*

After meeting and discussing with the collaboration team our Big Ideas changed to

- significance of earth crust
- beneficiation (the importance of energy resources) and
- the environmental impact.

The first CoRe was constructed before discussing with the collaboration team. It indicates only what we knew before learning more on different learning materials about energy resources.

4.2.1. Construction of the CoRe

In this present study, the CoRe was constructed differently from Loughran *et al* (2004), which was constructed through consensus by number of experienced science teachers. The initial CoRe represented in black in table 4.1 was developed from our pre- knowledge and my first concept map. Various resource material was used to supplement my pre- knowledge. The responses to the prompts/questions were obtained from our prior knowledge and learning material. It was not easy to fill answers to the prompt since my content knowledge was limited. Answers to prompt 3 and 4 in Big Idea 2, shows limited knowledge about the topic. It was difficult to answer questions such as "what else you might know about this idea (that you don't intend students to know yet)" because of insufficient content knowledge and lack of teaching experience for the topic.

The second part of the CoRe in the consolidated CoRe table 4.1, which is highlighted in yellow was added after meeting with the collaboration team and discussing the first CoRe. The collaboration team helped us with more teaching material which was used to fill prompts for the second CoRe. This CoRe was also used to develop the first set of lessons which were used for teaching. The final part of the CoRe highlighted in green in table 4.1 was developed after teaching both classes. We developed this CoRe after meeting with my colleague and consolidating our challenges. Below is an explanation on how the Big ideas that are shown in the consolidated CoRe were developed.

4.2.1.1. Construction of Big idea 1

Big idea 1 was about the significance of earth crust. It was important for learners to know more about the importance of earth crust. During the initial stage of the brainstorming of the big ideas, our initial big idea was about mining. My intentions about this big idea was for learners to know more about mining. After meeting with the collaboration team and discussing I realised that it was important to modify the Big Idea to the significance of earth crust. This knowledge will enable learners to understand more about exploiting the lithosphere, for example the composition of earth crust and the location of different elements. Learners will be in a position to explain the form in which minerals are found in the earth crust. It was not easy to fill the prompt 3 because the topic is more of geography than physical science.

As an important aspect of the CoRe (teaching methods), during the first phase I did not have any specific teaching method to use for explaining this Big Idea, therefore I resorted to the suggested traditional way of teaching, that is whole class teaching. The discussion we had with the collaboration team after teaching the grade 11 helped me with the construction of the final CoRe and filling prompt 7. My fellow master's students explained how the use of practical activity had an impact on learners' understanding of this Big Idea.

4.2.1.2. Construction of Big Idea 2

My second Big idea was about energy issues. Energy issues include all the LO's as prescribed by NCS (NCS document, 2003). It was easy to fill the prompts from top to bottom, though it was not easy to come up with strategies that will enhance learners' understanding. This knowledge will enable learners to understand energy resources, learners differentiate between renewable resource and non- renewable resource. I used group work as a strategy to get learners' understanding on energy resources.

4.2.1.3. Construction of Big Idea 3

Big Idea 3 deals with the social impact of mining as per requirement of the NCS. The involvement of social impact in the science curriculum is new, therefore using role play as a teaching procedure for the first time was a challenge. Filling the prompts in this Big Idea was not difficult because the content is embedded in our context . Filling the prompt of 'ways of

ascertaining learners understanding was more challenging, I could not think of any method to assess the role play. The Big Idea enabled learners to present ethical and moral arguments from different perspectives to indicate the impact of different scientific and technological applications. Below is a table that shows the consolidated CoRe.

Table 4.1: *Consolidated CoRe*

	Significance of Earth Crust	**Energy Issues**	**Environmental & social Impact**
1. What do you intend students to learn about this idea?	Lithosphere has different rocks with different chemical composition; -Location of specific minerals determined by natural processes -Where and in what form different minerals & elements can to be found -Some elements are found as elements and others are in compound form.	Renewable and non-renewable energy resources.	Scientific decisions can affec how people live.
2. Why is it important for students to know this?	-This will help in understanding the different types of mining. -To appreciate the power connectedness of natural processes -What people did before mining from stone age to iron age – development of technology	Sustainable development they have a part to play	-Decision taken by people now can affect the future generations -There are advantages and disadvantages of mining. - to know the effects of carbon dioxide during the burning coal
3.What else you might know about this idea (that you don't intend students to know yet)	-Earthquakes, plate tectonics, - Detailed elemental composition of the lithosphere - Microscopic structure of minerals	-Learners do not need to know the chemical formula of coal. But a simple formula of sugar/octane can be used to show combustion.	
4. Difficulties/limitations connected with teaching this idea	-Focusing on chemical composition rather than types of rocks. - Creating suitable representations of the real thing - Understanding proportion	- Learners can try to put in global warming when we are discussing coal combustion but that must be discussed in the next chapter- atmosphere.	-Biasness. Controlling emotions. Other learners can always be thinking about negative things.
5. Knowledge about students thinking that influences your teaching of this idea	-Understanding scale, e.g. thickness of the crust -Lithosphere is done in grade 10 geography.	- Everyday knowledge of coal usage, solar system, water, nuclear energy Oil refinery done in grade 10- chemical systems.	- Use the JHB context of the mine dumps. -Safety of the miners in the mines.
6. Other factors that influence your teaching of this idea	Use a scientific approach so that they will be able to integrate science and geography. -Possible local interest	Allow learners to use their everyday knowledge to understand their roles in sustainable development	Use the knowledge of what is happening around t them.
7. Teaching procedures		Help learners to work through the text in the extract.	Present a scenario s to explain underlying concepts.
8. Specific ways of ascertaining student understanding or confusion around this idea. (Include a likely range of responses.)	Report back from group discussions	-Learners will draw concept maps. -Written questions and answers.	- Group discussions. -Role play

4.3. Development of the PaP-eRs

The PaP-eRs are narrative accounts which include critical incidents in classroom teaching, learner's contribution and my reflection on the lessons. It captures my PCK while teaching the lesson. The papers below are processed data constructed from transcribed sections of video tapes taken during classroom observations, data taken from my journal and learner's worksheets. A brief description of the lesson was given at the beginning to highlight the procedure of the lesson.

4.3.1. PaP-eR on energy resources and its uses

This PaPeR begins after the class has already done some activities on coal and its effect on the environment in the form of research, presentation and discussion in class. The research was mainly on the effects of mining on the environment therefore it covered most of the our big ideas which are indicated on the CoRe. Already learners in this lesson have an idea about fossil fuels and their impact on the environment. I introduced the lesson by asking learners what energy is and then asking them to give different sources of energy. I was aware that learners sometimes know the definition of energy and know the different types of energy but do not understand or even know the principle of conservation of energy. When learners were asked to give sources of energy it was evident that learners confuse sources with types of energy.

The lesson proceeds, with learners giving examples of the different forms of energy but could not give the principle of conservation of energy. I explained the idea of conservation of energy using a cup on the table as an example. Below is an extract from the lesson on the explanation of conservation of energy.

> **Teacher** ***"****a cup resting on a table possesses gravitational potential energy, if the cup falls the gravitational potential energy is converted to kinetic energy, as it reaches the floor kinetic energy is converted to sound and heat energy"*

As the lesson proceeded, the flow of ideas was mainly from teacher to learners. The learners were actively involved in the lesson by answering different questions or completing the sentence where the teacher paused for the class to complete a sentence. I reflected in my journal that this was my traditional way of teaching. I then invited learners to think about a company who is selling a product and wants customers to save the product e.g. ESKOM. ESKOM is a company that sells electricity but every winter they encourage people to save energy. This question required learners to think about why it is important

to save energy resources and helped learners to understand that often everyday language or commercial language differs from scientific language.

To help my student understand more about the concept of saving energy resources and warn them about the use of everyday language, I then asked them about the message usually appearing on their TV's which says " save energy". The question asked was

Teacher ' *Is it correct to say save the energy and if it is wrong, why?*

I reflected, that the question was asked in order for learners to conceptualise the conservation of energy principle and make them aware of the shortage of energy resources.

I then gave learners an activity to discuss in groups. The activity was an introduction on renewable and non-renewable resources. Background information was given to support their prior knowledge. Learners were suppose to read the background information and discuss their answers with their group members. As the discussion progressed, I walked around and listened to the discussion.

I reflected that 'the group activity will assist learners to develop their scientific language, communication, reading skills and also to help remind them of what they already know about energy resources. As I was walking around, I noticed that most learners were using their primary language during the discussion.

During their discussion, it was evident in one group that they confuse sources of energy with types of energy. In most groups there was a debate whether biomass was non- renewable or renewable. Conversations like the following tell me they were getting the idea, but the use of everyday language was dominant.

> **Learner 1**: Why do you say biomass is non renewable, what is your understanding of renewable?
> **Learner 2:** renewable means something that can be used again and again (**into ongayiphindaphinda**).
>
> *When I heard ideas like this I kept them in my mind, for further discussion with the learners and for correction of the use everyday language.*

During the classroom discussion I probed learners about their understanding of renewable resources and helped them with the use of correct scientific language. Lastly, in the whole class discussion I realised that some learners struggled to give me examples of sources of energy most learners gave me types of energy, while answers were given in the background information provided. I reflected in my journal that reading text was a problem for most learners and that I had to emphasize the importance of differentiating between the types and sources of energy. What follows is a reflection of my first lesson on what to be emphasized in the next class

- *Introduce the lesson by asking learners give their own understanding of energy sources and types of energy.*
- *Encourage learners to read and understand before answering questions.*
- *When writing on the chalkboard take extra care that what is written has the same meaning as what I actually said. For example I said, " during the formation of coal no oxidation takes place" but on the chalkboard I wrote - dead plants------ peat—oxidation ----------coal.*

The explanation of the formation of coal was less abstract to most learners because they have done it in Geography. I must make it clear that it was not easy to answer some of the questions learners were asking for example answering questions such as

> *" how are different types of coal formed, how is the first grade coal formed and how is the lower grade coal formed?"*

Elaborating on the learners answer was not an easy task because I was not so sure of the answer myself. I did mention the flow of river and mineral deposit. But to summarise the answer I asked learners to go and make some further investigation on this question and to come with their findings the next day.

4.3.2. PaP-er on Home activity

> *This PaP-eR was written to explore learners' understanding and their ability to read and understand a given text.*

At the end of the lesson, I asked learners to draw flow diagrams of how coal is formed individually at home. The next day, looking at their flow diagrams and concept maps I noticed the following. Most maps and diagrams had sentences in them not concepts, links in the flow diagram started from sun. In the flow chart showing the formation of coal most learners have "oxidation" instead of "no oxidation". Example diagram below

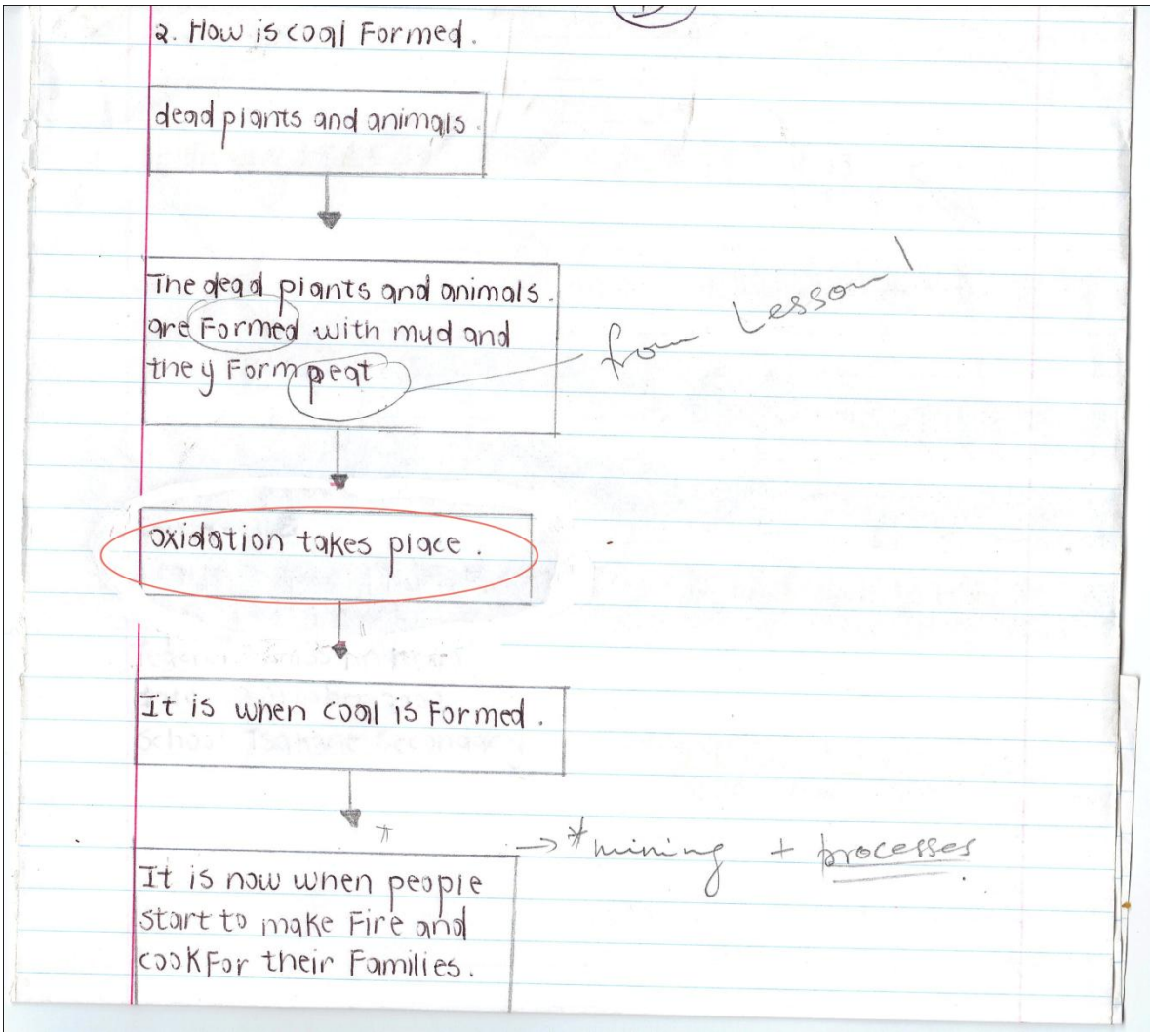


Figure 4.1: *Learners' flow diagram*

During the discussion with learners about their flow diagram it was evident that the learners did not know the difference between flow charts and concept maps and how to construct them.

I reflected that I must highlight the important point about concept maps and flow diagrams in the next lesson.

4.3.3. PaP-eR on environmental impact of mining (Role-play)

This activity was trying to make science relevant to learners and to getting them to be interested.

I used the role-play as a teaching approach for the environmental impact of mining. In the role-play learners are assigned roles to play. They act different roles in a certain community where there was a proposal to re-open a closed mine. For example Learners acting the same role were to meet first and

discuss their role. They were given briefing statements to read and discuss their points which they will use when meeting with other roles (appendix **C**)

While discussing I wandered around to get what was discussed, most learners were using their primary language. Then lesson proceeds with different roles meeting as community to discuss the issue. The mayor was in charge of chairing the meeting. The argument between the different roles was interesting because most learners were referring to a nearby mine that has been closed when arguing about their points. I realised that learners were afraid to use their primary language as I walked past them. So I gave them the go-ahead to use their language.

> *I reflected that the responses from this class exceeded my expectations considering that I was referring to them as a quiet or non responding class. I also noticed that after giving learners the go-ahead to use their primary language everyone was now participating. The response I got from this class made me realise that teaching in science in context is important and will help learners to notice the relevance of science in their everyday life. I also reflected that assessing learners was still a challenge when using role-play.*

The lesson ended with the mayor giving the decision to the community.

4.3.4. Discussion on PAP-ERS

According to Loughran *et al.,* (2004) PaP-eRs offer one way of capturing the holistic nature and complexity of PCK, more than is possible in the CoRe. As PaP-ERs are a narrative story which clearly provide an account what happens during the lessons, they also shows different aspects of PCK, for example teachers' knowledge of the students, prior knowledge and curriculum. I tend to agree with Loughran *et al.,* (2004) that

PaP-eRs offer one way of capturing the holistic nature and complexity of PCK, more than is possible in the CoRe.

4.4. Chapter summary

The CoRes and PaPeR were discussed, the accounts of how they were constructed was also highlighted. The next chapter will outline the evolution of my PCK.

CHAPTER 5

Evolution of pedagogical content knowledge.

5.1. Introduction

This chapter outlines an analysis of my content knowledge and my PCK. In this chapter, firstly the data sources will be outlined, followed by a description on how the data was analysed. Central to this study is the analysis of the PCK and content knowledge. The chapter will end by giving concluding remarks.

5.1.1. Data sources

The main aim of this study was to capture the evolution of my content knowledge and my PCK through the use of self-study and reflective teaching. Therefore, data from the video recordings, reflective journal, learner's worksheet and concept maps drawn by the educator were used. The PaPers and the CoRe, which were constructed, were also used as data. The data collected was analysed to locate the evolution of my PCK.I watched the video several times over, then I marked section of the video that illustrated certain themes. I then drew out themes based on the components of PCK as outlined by Geddis and Wood (1997).

The analyses of this study was based on five components of PCK outlined by Geddis and Wood (1997), which are subject matter representation, curriculum materials, learner's prior concepts, instructional strategies and curriculum saliency. The transformation of subject matter is dependent on the types of knowledge listed above. The process is an integrated one, the types of knowledge are not discrete they influence and affect one another. The teacher's ability to transform subject matter knowledge is shaped by the different kinds of knowledge (Geddis and Wood 1997). The elements outlined by Geddis and Wood (1997) illustrated earlier in chapter 2 (figure 2.2) fit to my data and, the connections between data and categories are noticeable to me. The data collected was carefully reviewed in order to establish whether they relate to various kinds of knowledge according to Geddis and Wood (1997). Hence, below in figure 5.1 one additional theme emerged from the data and was added to the components namely, knowledge about student understanding.

Knowledge of student understanding refers to the knowledge of how they will respond to teaching approaches, designing teaching which assist in different learning style, maintain the learner's interest and sensitive to individual responses to exposure in role play activities.

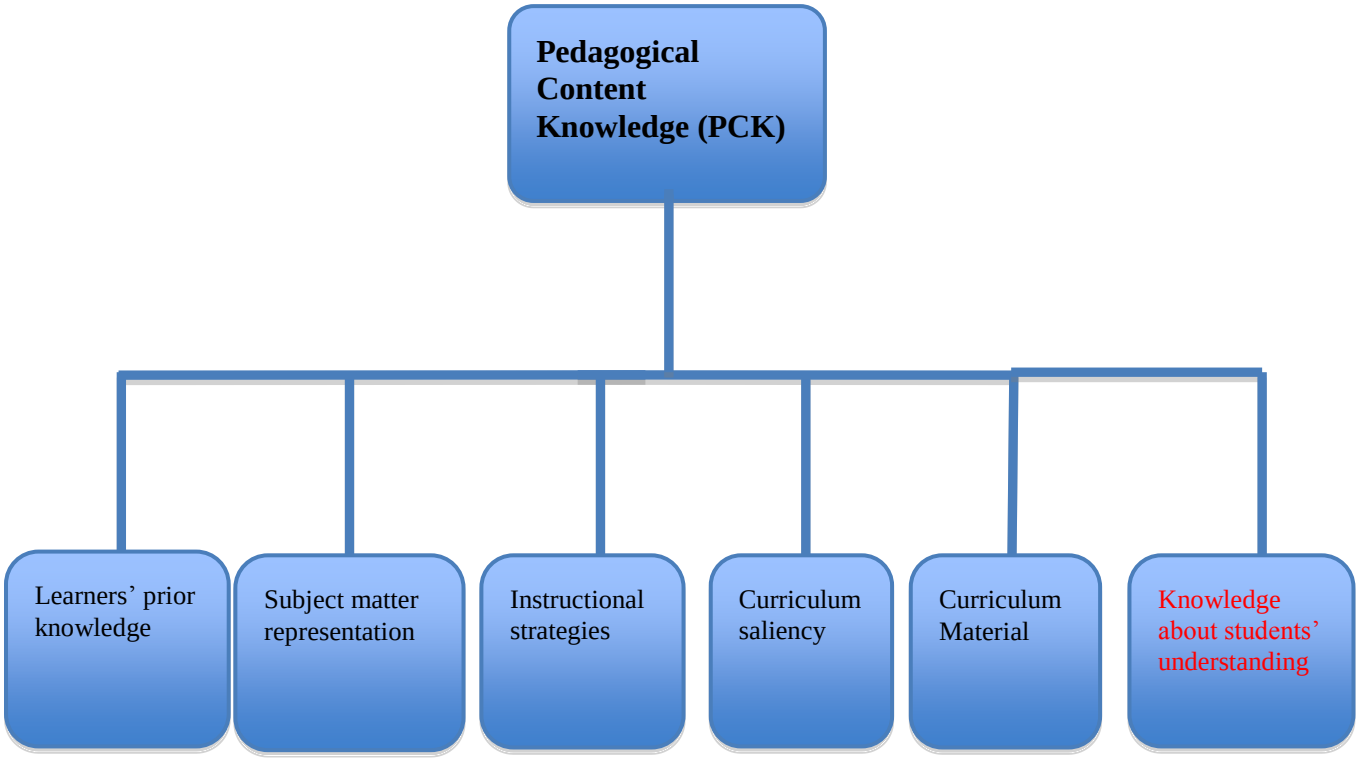


Figure 5.1: *Components of teacher knowledge that facilitate transformation of subject matter (modified from Geddis and Wood 1997)*

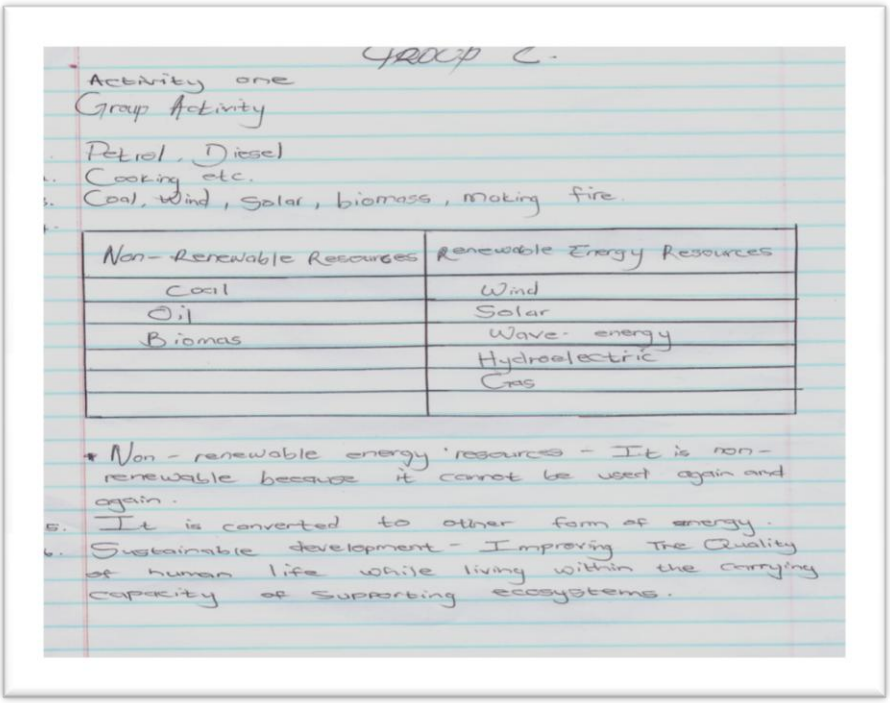
This framework is appealing to me because the five categories are instrumental in determining the teacher's ability to transform subject matter knowledge. Therefore the framework would be used to show how I transform the content knowledge into forms that are accessible to learners. The following diagram shows the modified components of PCK. However it should be noted that Geddis & Wood (1997) acknowledged that the transformation of subject matter occurs in no particular order since teaching and learning can be modified continually. The transformation of subject matter is discussed below under the categories outlined above.

5.2. PEDAGOGIC CONTENT KNOWLEDGE ANALYSIS

5.2.1. Learner's prior concepts

Geddis and Wood (1997) pointed out that this refers to the prior knowledge, alternative conceptions, misconceptions, awareness and learners difficulties concerning the concept to be taught, which helps in interpreting learners actions as well as planning effective instructional strategies. Knowledge of the learner's conceptions about a certain topic is essential i.e. the knowledge of preconceived ideas helps the educator to plan effectively. With regard to learner's prior concepts, learners were given an introductory

activity (appendix C) to probe their prior knowledge on energy issues. I used the discussion of this activity as an introduction to the energy resources lesson. The data revealed that learners were able to name the different forms of energy resources but had difficulties in understanding the law of conservation of energy. Below is an example of the group worksheet which shows learners understanding of the forms of energy resources. It must be noted that learners said petrol is source of energy.



GROUP C.

Activity one
Group Activity

1. Petrol, Diesel
2. Cooking etc.
3. Coal, Wind, Solar, biomass, Making fire.

Non-Renewable Resources	Renewable Energy Resources
Coal	Wind
Oil	Solar
Biomas	Wave energy
	Hydroelectric
	Gas

* Non-renewable energy resources - It is non-renewable because it cannot be used again and again.
5. It is converted to other form of energy.
6. Sustainable development - Improving the Quality of human life while living within the carrying capacity of supporting ecosystems.

A sample of learners' activity.

In lesson one as seen in the video 1 (8 minutes) it shows that learners were actively involved giving answers during the lesson. The video evidence of the first lesson also highlighted that the use of primary language can aggravate misconceptions. Below is an extract taken from this lesson:

Teacher :' *what is your understanding of the term "renewable"*

Learner A: *' into ongayiphindaphinda' something that can be used again and again'.*

The statement above when translated to English is scientifically wrong. This is wrong because something that can be used again and again does not mean it can be recycled. I effectively address the issue of this misconception by using a cold drink can as an example. I explained to the learners that 'though a cold drink can is said to be renewable but that does not mean it can be used again and again, but it means it can be recycled'. I also used the cold drink to explain the conservation law of energy. The extract below show how the can was used to explain the conservation law of energy.

Teacher : *" the can possess gravitational potential energy as it on the table, but if it falls to the ground the gravitational potential energy is converted to kinetic, heat and sound energy".*

5.2.2. Subject Matter Representation

Geddis and Wood (1997) advocates that the knowledge of models, simulation, analogies, demonstrations and experiments helps to communicate and effectively transform the subject matter for learners to comprehend the content. I used chalkboard to emphasize what I was saying. It was challenging to get subject matter knowledge that can be used immediately. Learners , however were given a worksheet where they had to draw a graph to enhance some of the concepts explained. In appendix C the example of activity is given..

5.2.3. Instructional Strategies

This term refers to as described by Shulman (1986) as the modes of teaching, organizing, managing and arranging the subject matter. The lesson in the first class began with a group discussion, which aimed at finding learner's prior knowledge, and then followed by whole class teaching and question method. The data revealed that most of the lesson were teacher centred, though the guided role play was also used. Learners were actively involved in the lesson by giving answers when asked. I asked them questions where they had to fill in certain parts. This is described by Brodie, Jina and Modau (2009) as a 'leading through a method'. The extract below show how the lesson progressed.

Teacher : *Give the different sources of energy?*

Learner A: *solar*

Learner B: *water*

Learner C: *air eh—wind*

Teacher : *are you saying wind from air?*

Learners: *wind Mam*

The extract above shows that I was leading the learners with questions trying to find they prior-knowledge.

The strategy I used for the first class is summarised below. This shows the sequence of how the lesson went. The diagram below shows that the lesson started with a worksheet given to learners for discussion and answering the questions on the worksheet. The intention was to get learner's prior knowledge; this was then followed by whole class discussion. The learners gave their answers(see video 2, in 7 minutes 20 seconds) and we then elaborate on some answers and I addressed some misconception. I then started the lesson for the day by using whole class teaching, even though questions were asked but I was the source of information most of the time. Learners were then given a take home assessment activity, which

was aimed at getting their understanding of what was taught. The second lesson begins the next day with doing remedial work for the take home activity, then the role-play. The strategy used can be summarised as follows.

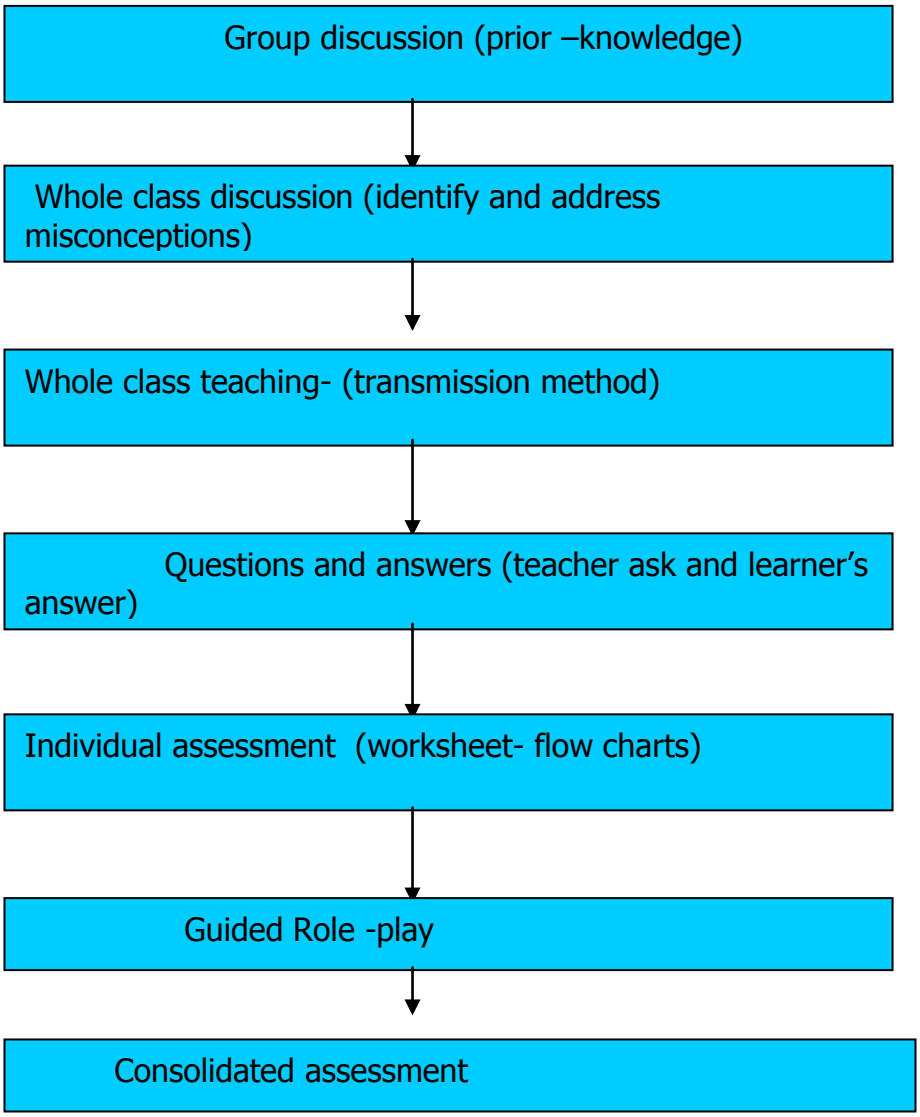


Figure 5.2*: The strategy I used to teach class A*

The sequence of above strategy was then changed for class B, for the following reasons

- In class A, learners seemed not to be interested in the content knowledge and from their answers for the take home activity it showed that they did not comprehend the content well
- I was not sure which sequence would work efficiently for this knowledge area to get maximum results.

In class B the lesson began with role-play to generate interest and to relate science to everyday life. It must be highlighted that this strategy was used for the first time in class B. At the beginning of the lesson

learners were confused and not so sure what to do. Time was wasted explaining to each group what they were supposed to do. Using this approach in class B I realised that learners were more actively involved in the lesson especially during question and answer time. Though I must acknowledge that learners were using their primary language, I also encourage them to use their primary language. Below is the evidence of learner's flow diagram from the two classes showing their answers for take home activity. The first flow diagram is from sample of learners work from class A, where the role play was done as the last lesson. The activity was given to them as a home activity and learners were given information sheet to read first, then answer the questions. This sample was answering the question which was as follows.
Question ; Draw a flow diagram to show the formation of coal.

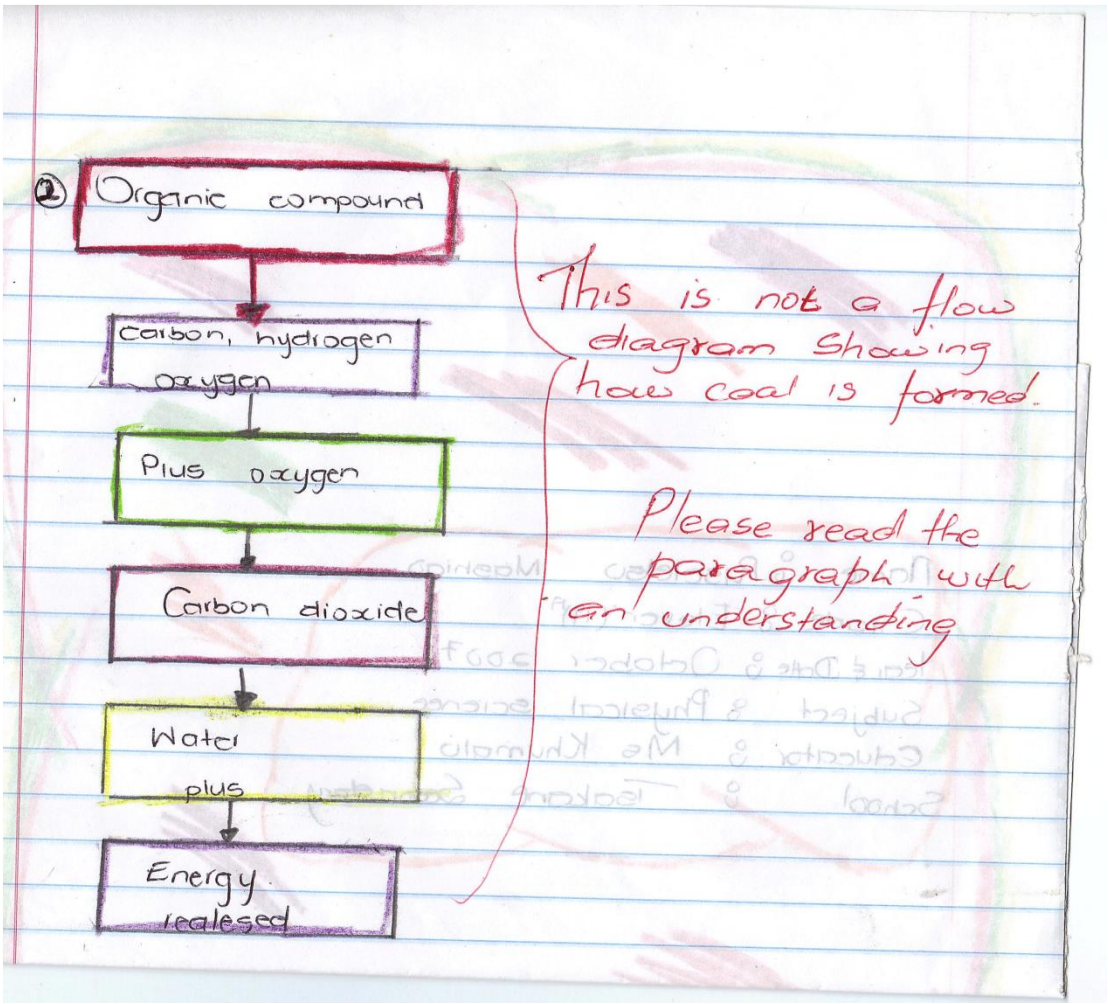
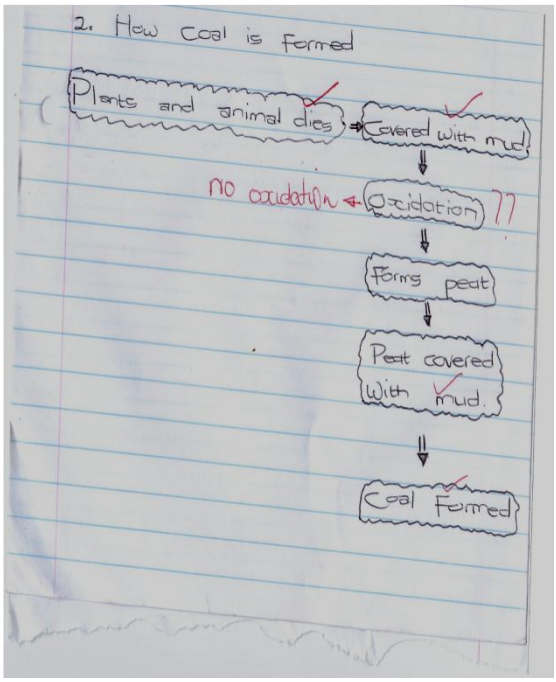


Figure 5.3: *Learner A flow diagram (from Class A)*

The diagram above is a sample of flow diagram from the first group, most learners in this class shows lack of understanding hence they transcribe the word reaction which was given on the home activity as

was, see (**Appendix E).** Learners take facts as they are given to them without understanding or analysing them. It is evident from the sample above that learners did not understand the difference between flow diagram and concept maps. And it is also evident that when learners lack interest , they fail to read an extract given to them.

The following flow diagrams are sample from class B, where the role play was done immediately after the activity on prior knowledge.



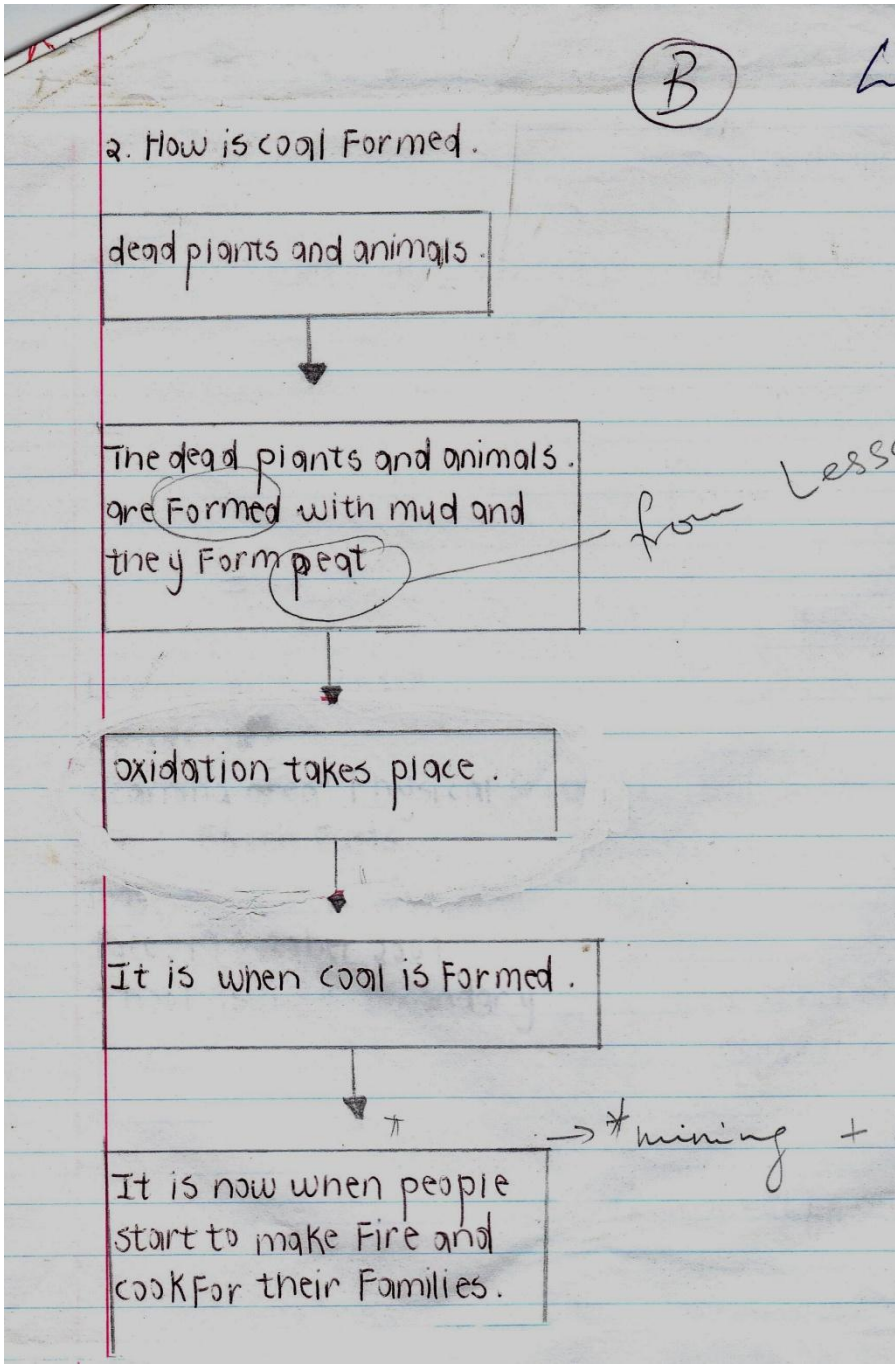
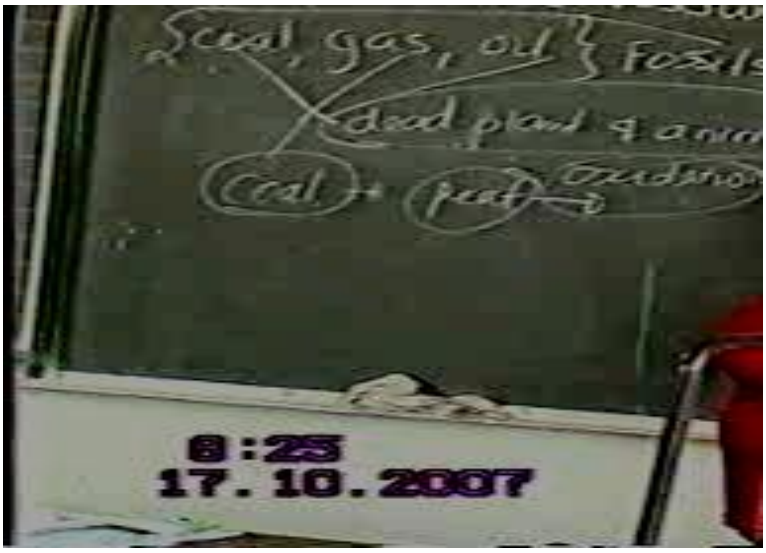


Figure 5.4 : *shows two flow diagrams from learners in class B.*

The diagram on the left shows that learner understood the steps on how coal is formed. The learner showed the sequence of the formation of coal well, except that the learner wrote oxidation instead of no oxidation. The diagram on the right shows that the learner partial understood the process hence, he is confusing the process of the formation of coal with the mining process. It must be highlighted that most learner's wrote "oxidation" instead of 'no oxidation' as shown in the examples above. This shows that learners mirror teacher's action (**appendix F**). Below is a snapshot that show where the learners got the

word oxidation from. The teacher wrote on the chalkboard ‘oxidation’, though the transcribed notes from the video indicate that teacher said “NO OXIDATION” as seen in the caption below.

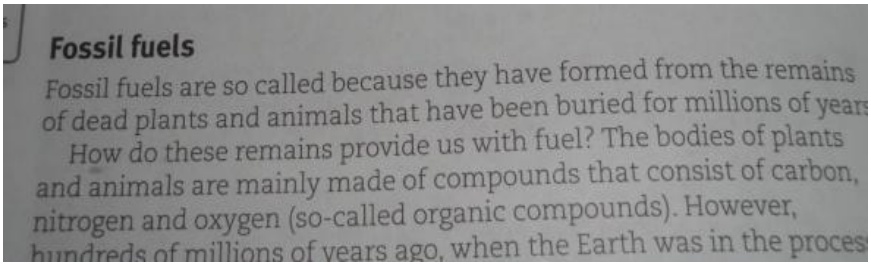


Caption 5.1:*(video 1, Lesson 1: 25 minutes)*

5.2.4. Curriculum Material

The knowledge of curriculum material together with instructional strategies helps teachers in the transformation of content knowledge (Geddis & Wood, 1997). I used solely textbooks as curriculum material, and the material we developed (appendix C) with my colleague because it was a new topic therefore not enough material was present. The material developed was a helpful tool to transform my subject matter knowledge, it also helped in sequencing the lesson for better understanding. I managed to adapt a role play that I got from the textbook. I must acknowledge that it was the first time to use a role play in class, I managed to use a mine which was closed to our community to explain to the second group.

The lack of curriculum material in this topic was another factor that led to the use of whole class teaching, teacher centred, question and answer method as mode of teaching. However it must be highlighted that due to insufficient content knowledge it was difficult for me to correct statements on the textbook such as ‘ fossils are formed from remains of dead plants and animals’ below is an extract taken from the textbook. The extract below show the explanation on how fossils were formed. It was very difficult for me to differentiate the general statement, so to say that coal is formed from dead plants.



Fossil fuels

Fossil fuels are so called because they have formed from the remains of dead plants and animals that have been buried for millions of years. How do these remains provide us with fuel? The bodies of plants and animals are mainly made of compounds that consist of carbon, nitrogen and oxygen (so-called organic compounds). However, hundreds of millions of years ago, when the Earth was in the proces

Extract taken from Grade 11 textbook.

Learners were also taught that coal was formed from dead plants and animals (see extract above and figure 5.4). It was only corrected by subject specialist in one of the research meetings, that coal was formed from only the remains of dead plants not animals. The following extract was taken from a sample of the transcribed notes from meeting with the collaboration team (see APPENDIX F).

Chemistry Expert: "*Maureen why did the most of your learners write coal is formed from dead plants and animals in their maps?"*

Me : "*That is how it is explained in the textbook, why is it wrong?*"

In my journal I commented as follows.

" *it was so challenging to interpret information from a text book if you lack content knowledge"*

5.2.5. Curricular Saliency

This term refers to the dilemma of the breadth versus the depth of the coverage of the subject matter. This knowledge domain is observable from the teacher's decision on the sequencing of the content knowledge and decision to leave out other aspects of the subject matter, which can be covered later or has already been covered in the previous grades. The concept map (figure 5.4) shows lack of progression of the content from grade 10 to grade 11. This is in line with Gess-Newsome and Lederman, (1999) view that novice teachers with limited content knowledge often focus on the teaching activity as a means of portraying content, with little consideration for larger issues of disciplinary structures, connections of concept within a lesson or across a curriculum.

5.2.6. Knowledge about students' understanding

This includes knowledge about student's motivation, specific difficulties and inabilities concerning the content of scientific models. With respect to knowledge about students understanding data revealed the following. Having taught the group in grade ten the previous year I was aware that learners have proficiency in language of instruction but some learners are below grade level. Learners were given

permission to use their primary language especially during the role -play where everyone was to participate (see appendix C, ***role play***). The use of primary language in class led to learners participating freely and enhanced learning.

Allowing students freedom to explore gave me an opportunity to learn about their understanding of chemistry in real life. I was taken aback by their response to this activity and their increased responsiveness to the use of their primary language.

I reflected

> *As I was walking around, most learners were using primary language during their discussion. It was evident that in one group they confused sources of energy with types of energy. Debate whether biomass was non-renewable was predominate in most groups. Conversation like that showed me that they are getting the idea.*

5.3. Analysis of content knowledge

Content knowledge was defined as knowledge of facts, concepts, principles within a content, knowledge of the relationship among these foundational ideas and the knowledge of principle of inquiry and values inherent to the field (Wilson, 2004). This includes knowledge of theories and principles of teaching. My content knowledge was analysed using following concepts maps. Figure 5.4 indicates the concept map of my knowledge during the initial phase of constructing the CoRe and figure 5.5 indicates a concepts map drawn after the consolidated CoRe.

The initial concept map below shows insufficient content knowledge. The map does not indicate the connection of the new knowledge to the prior knowledge (grade 10 work) and there are no integration among the concepts. It also highlights the need to empower teachers with progression across the knowledge grade, because the concept map lacks cross-links to show how the concepts are related. The concept map only shows what is essential for grade 11 and does not show how the content knowledge progressed from one grade to another. This reflects inadequate curriculum and content knowledge on my part.

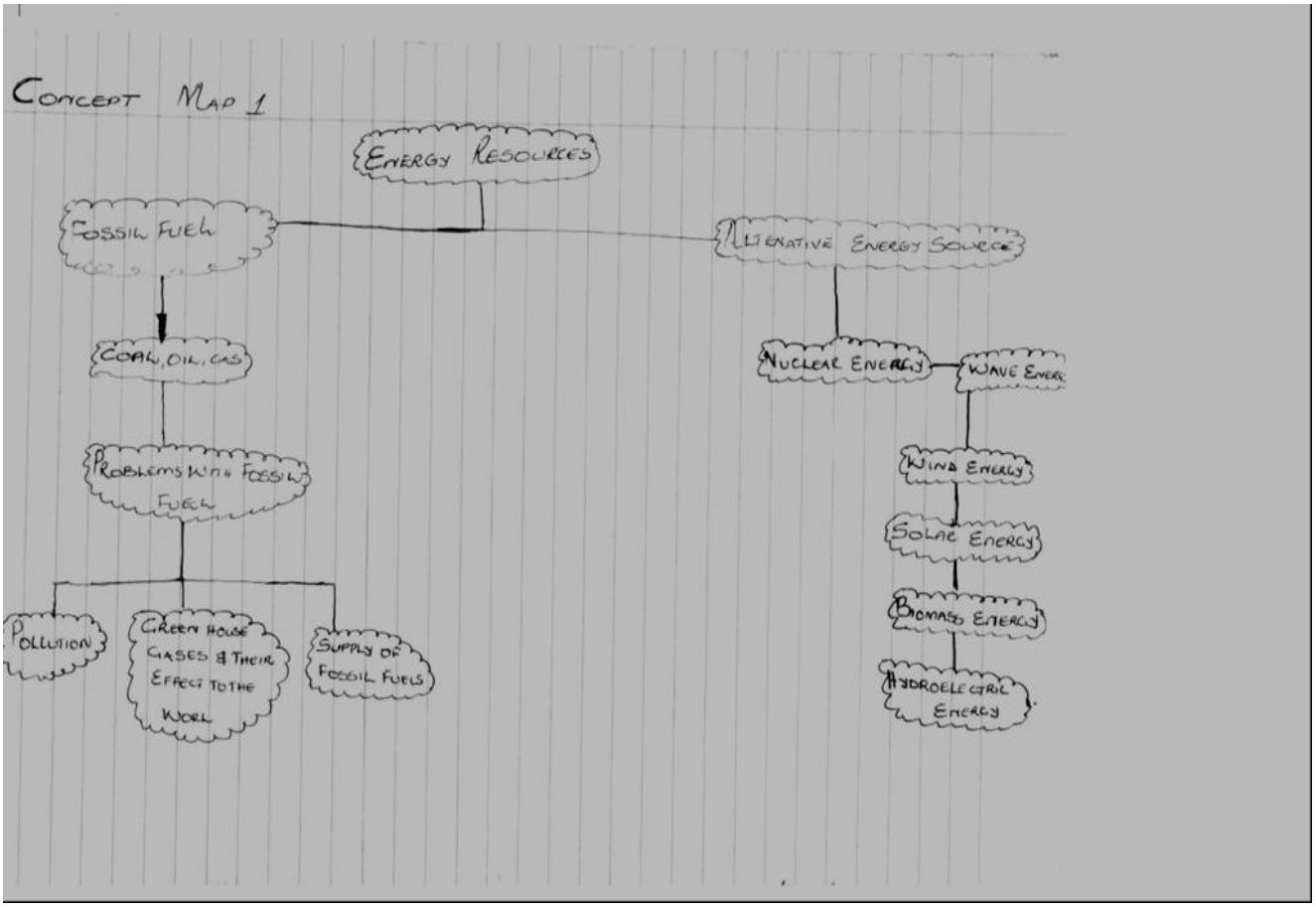


Figure 5.5: *Concept Map 1*

Insufficient content knowledge was also highlighted in the initial CoRe that it was difficult for me to come up with strategies that can enhance learning, giving ideas that can hinder or enhance problematic aspects (see initial CoRe). It was not easy to fill the table that was used to develop the CoRe. For example I experienced difficulties filling the prompt to the question "what else you know about this idea that you don't intend students to know yet?" The effect of teaching with insufficient content knowledge was evident when learners asked me questions. The following excerpt was taken from the transcripts of lessons.

> ***Learner**: "how are different types of coal formed, how is the first grade coal formed and how is the lower grade coal formed?"*
>
> ***Teacher**: "remember the different types of coal e.g. high rank coal to low rank coal……. I am not so sure about that which means we all have to go and find more information on that, but it has to do with the type of coal."*

Elaborating on the learner's answer was not an easy task because I was not so sure of the answer myself; it also shows lack of confidence and inadequate knowledge of subject matter.

There is considerable development in the map, showing development in curricular knowledge and the different grades are identified with some cross linkages see concept map below. For example in grade 10 learners learn about carbon cycle, which help as prior knowledge for grade 11 when teaching about the for formation of coal. Knowledge of curricular is also highlighted during lesson preparation (appendix C), the first lesson is designed to access learners' prior knowledge.

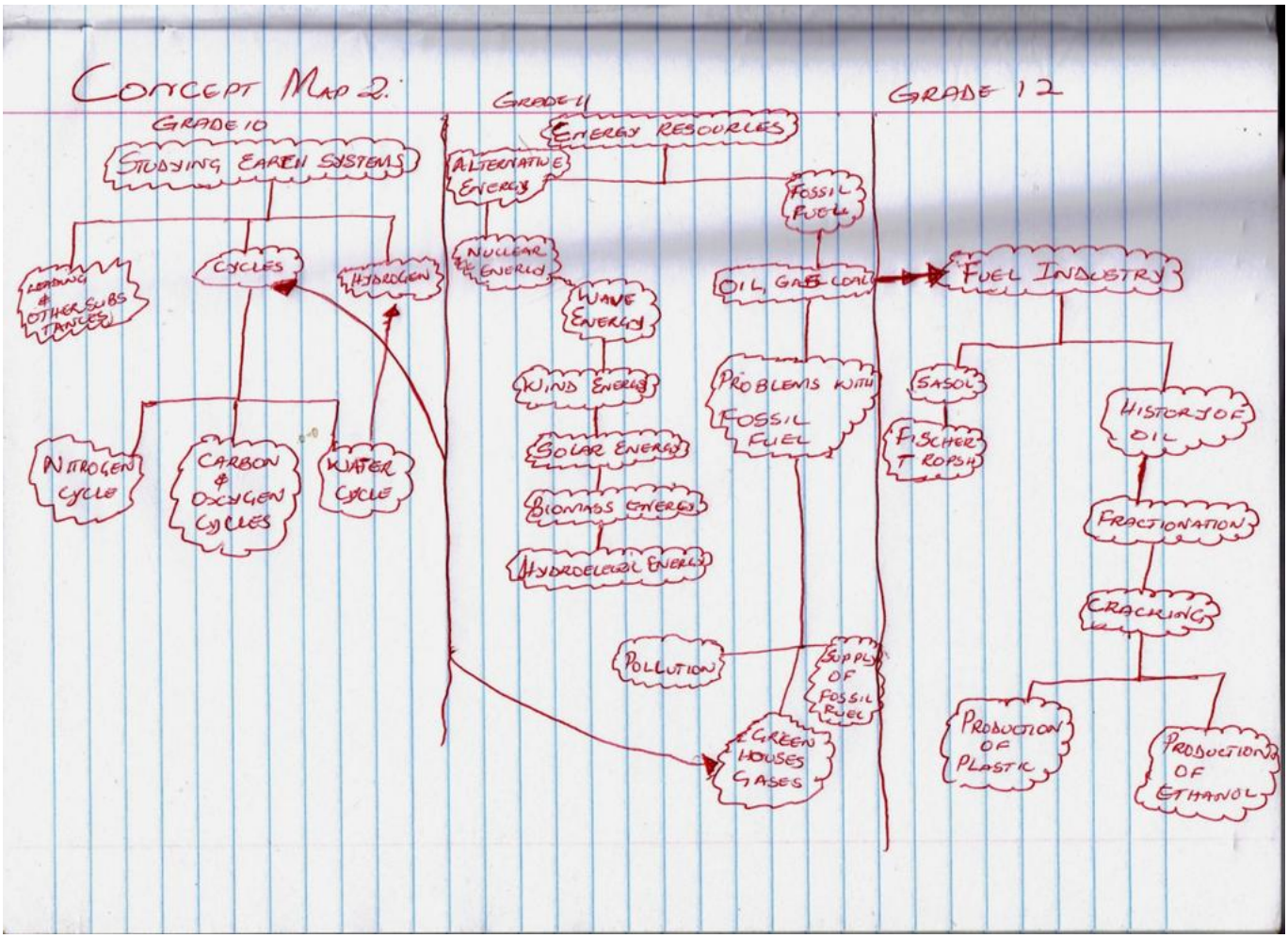


Figure 5.6: *Concept map 2*

However one important content error remains in the placement of renewable "green" resources such as wave energy, wind energy and solar energy alongside its traditional opponent, nuclear energy. The error was highlighted by the chemistry expert during our meeting. Apart from the error mentioned above, the development of content knowledge was highlighted in the development of the CoRe. The CoRe

(Loughran *et al.*, 2006) shows identification of big ideas and answering the key prompts related to the big ideas.

The consolidated CoRe shows growth in my content knowledge (table 4.1 in chapter 4). The development of the CoRe helped in the growth of my content knowledge. During the initial stage of the development of the CoRe I had only three big ideas, which were renewable resources, non- renewable resources and environmental impact. The lack of content knowledge was further highlighted when I was preparing the learning material.

5.4. Implementation of learning outcome three

The profile of implementation proved to be a useful tool in tracking my implementation of learning outcome three in the new curriculum. The implementation of a new curriculum is a long term, ongoing process in which teachers are given a chance to change their practise. One of the four observed lessons revealed that I was operating in Level 2 strategies though I have incorporated the aspects of Level 4 on science in society dimension. In lesson one where learners were to work as a group, a question on sustainable development was asked. This was evident in the video (video1, in 13minutes), I further asked question on this to ascertain whether learners understood this in everyday life. I managed to find applications of science in everyday life, but because of lack of content knowledge I could not meaningfully interact with the learners. For example the snap shot below shows learners discussing in group during the role play.



Caption 5.2: *Snap short showing learners participating in a role play.*

Learners in this activity were participating freely and every learner was participating. However, I did not conclude the role play in a meaningfully way, it ended while learners were still arguing.

5.5. Chapter summary

In conclusion, the framework used above to locate the teacher's growth in PCK revealed a growth in my PCK, however an essential factor that retards the growth of PCK was highlighted above as insufficient content knowledge. In particular, the change of the sequencing of the strategy .

CHAPTER 6

RECOMMENDATIONS AND CONCLUSION

6.1. Introduction

In this chapter the overall conclusion of the study will be given. This consists of the main findings; reflections of the study, recommendations and the limitations of my study will be outlined towards the end of the chapter.

6.2. Overview of the study

The study intended to find how I transform my subject matter knowledge when teaching a new topic to grade 11's. Content Representation (CoRes) and Pedagogical and professional- experience Repertoires (PaPeRs) were captured and documented to articulate my PCK. The CoRes and PaPeRs were also used to assist in analysis of data and thus represent a construction of what was observed in the lesson taught.

6.3. Critical reflection of the study

6.3.1. The methodology

Self- study as a research methodology allowed me to understand my own practice more deeply and help me to reflect upon my pedagogy. I needed to do self-study to observe how the topic unfolds in a view of developing my PCK. It is important to mention that I had a problem with self- study at first because I realized that my personal beliefs and ideologies would be challenged. I had to expose my content knowledge of teaching the energy resources to the collaboration team before engaging in teaching. This process was difficult for me because I have never exposed my teaching or beliefs to anyone.

Gess-Newsome and Lederman (1999) indicated that teachers with strong conceptual knowledge , have more knowledge on the topic, more connections and relationship to other topic. The study was based on developing my PCK and content knowledge for a new topic. Therefore, gaining understanding of the topic prior to teaching was important. Developing and exposing my concepts maps to the collaboration team was effective in that my limitation of the content knowledge was exposed as alluded in chapter 5. In developing my first concept map I had difficulties in making the concepts map more meaningful. I found myself writing only concepts with no relationships between the concepts due to inadequate content knowledge. The second concept map was more meaningful and shows relationships between the concepts. This was influenced by the fact that our collaboration team discussed my first concept map, and also the fact that I had a better understanding of the content. Through this process they were able to

support and encourage me to learn more. They also highlighted, addressed misconceptions and spot gaps in my content knowledge.

The collaboration team helped me to reflect on my teaching practice, this was challenging at the beginning of the process since I had insufficient language for sharing my thinking. This was also highlighted when I had to write my reflective journal. I found myself with scattering ideas not knowing what to write on my journal. It was difficult for me to write the journal every day especially during teaching and after teaching. This was evident when analysing my data that, other things I should have documented but I overlooked during the process. I realised that it was important to document all my reflections so to help in analysing data. According to Bryan & Abell in De Jong *et al.,(*2004) reflections can promote new insight into teaching specific topics.

CoRes in this study were constructed differently from Loughran *et al.*, (2004) CoRe, which was done with a group of expert teachers. I started constructing the CoRe on my own before working with the collaboration team. I encountered problems with coming up with BIG IDEAS, at first I thought they were sentences to describe your lesson. While I was busy with BIG IDEAS, I realised that I had insufficient content knowledge , therefore it was not easy to fill the questions in the CoRe. It was difficult to think of strategies to use and think of learners' prior knowledge. However, I was able to compare how my PCK developed with the use of CoRe's at different stages.

6.3.2. Discussion of the findings

6.3.2.1 Designing of lesson plans and teaching process

Using the CoRes and PaPeRs to capture and document my PCK helped me to gain insight on how and why to teach the topic in a particular way . The CoRe was a useful tool for planning my lessons. I was able to think about the learners prior knowledge, what activities to give them and which strategy to use when teaching. On the contrary it was challenging to answer the questions on CoRe due to insufficient content knowledge. It was a challenge for me to come up with 'BIG IDEAS"

I felt that the CoRe had a positive effect on the development of the lesson plan. The prompts in the CoRe helped me to think more deeply how to develop the lesson plans and implement them. Before teaching the lesson my colleague and I were invited to a teacher workshop, where we piloted our lessons. The questions asked by the teachers helped me to modify some of the lessons. The workshop had a positive impact on my confidence. Teaching the lesson was easy, I realised that it was not a challenge to teach

first lesson which was about different forms of energy. I was disappointed with second BIG IDEA 'beneficiations". It was not easy process for me to develop lessons on beneficiation, even the collaboration group did not help much with the little subject matter I had . I had to use different material even Geography material to learn more on this. It was difficult for me interpret the content in some textbooks, hence I had problems with understanding the different grades of coal and explaining that to learners was a challenge.

I was not confident and flexible with the content and I had to keep on referring to my notes for the second BIG IDEA. When learners asked questions in class , it was evident to me that my content knowledge was insufficient. Developing lessons on environmental issues was exciting to me, I saw this as a chance for me to incorporate the societal issues with science. I expected learners to relate to the mine which was closed a year ago in our area. It took me time to guide learners on how to perform the role play, as I was expecting them to understand this by reading the instructions. My frustrations increased as learners were struggling to come up with ideas on mining. I realized after teaching the second class that allowing them to use their primary language help in participation.

6.4. Summary of findings

The aim of the study was to investigate how I transformed my content knowledge and improved my practice particularly in the topic of energy resources and its uses. This section outlines the main findings and answers to the research questions.

6.4.1. Research question 1

How did my PCK develop as I developed the broad content of the energy resources and its uses into focused, teachable and comprehensible content?

Loughran *et al.,* (2004) suggested that PCK is difficult to articulate since it is an internal construct that many teachers innately possess, but rarely discuss among themselves. Bishop and Denley (2007) stated that PCK is the knowledge which combines other knowledge. Results from the study indicated that, with respect to PCK, my PCK improved over time. Though I must highlight that inadequate content knowledge retarded the growth of my PCK. My initial strategy for the first class was teacher-centred and did not give learners time to be engaged in class. The approach was adjusted for the second class where learners participated in a role play. This activity gave learners time to interact with the learning material and gain knowledge before they were engaged in the classroom activities such as the group activity.

Elaborating on the content knowledge was a bit difficult in particular with BIG IDEA 2, where the content was mostly geography.

A constructivist approach was used in both classes. Learner's prior knowledge was determined before engaging them in new knowledge, hence activity one in Appendix C probed for learners prior knowledge. I was able to explain the difference between forms of energy and the conservation law of energy using examples. The curriculum saliency shaped my PCK allowing me to plan more effectively. I was in a position to emphasise some aspects of the topic which would form foundation for subsequent topics. The growth of PCK was also evident when learners asked me about a question which I did not have an immediate answer for. I managed to convince them that we must all go and find the answer.

6.4.2. Research question 2

How did my planning and reflecting on practice change as I participated in the process of planning, developing and implementing the lesson plans.

The use of CoRes when planning the lesson was an effective tool, it gave me time to question my thinking on why and how the lesson must progress. Lesson planning is not the sequencing of teaching topics but it requires decision on broad learning outcomes and selecting suitable learning activities and assessment task. With regard to planning the lesson, it is important to highlight although it was challenging to use concept map, reflective journal and CoRe for the first time, but I changed my perception about them. This is because it proved to be an efficient way of planning what to teach, as it helped me to think , refine, reframe and develop actions that will enhance understanding.

Teachers with differentiated and integrated knowledge will have greater ability than those whose knowledge is limited and fragmented to plan and enact lessons that help students develop deep understanding. Implementing the role play for the first time in class was a challenge however, gained insight on how to do it better with the next group. Therefore with the second group it was more meaningful and learners actively participated. This is in line with work done by Setati (1998), that showed that the use of code switching encourage learner participation.

6.5. Discussion and Conclusion

The study has presented my case study and cannot be easily generalized. However, the study emulate a number of findings from the literature. My study replicate Rogan (2007,b) study on a particular school,

where teachers were willing to implement the curriculum but did know how to do so. In response to the curriculum implementation, though I managed to change some teaching strategies but it was superficial and revealed some misinterpretation. The sub-constructs classroom interaction has a clear overlaps with learning outcome three. This is evident when the content learned in class need to be transferred in the context outside classroom. Learners have to take responsibility of their own learning.

One important conclusion drawn from the study is that CoRe and PaP-eRs are valuable tools to capture the development of PCK. However, the development of PCK is an ongoing process. Shulman (1986,1987) emphasized the importance of content knowledge because without content knowledge a teacher cannot have a good PCK.

6.5.1. Limitations of study

The methods used for collecting data was difficult to use, especial at the beginning of the process of collecting the data. I felt that some data was not captured because I was not comfortable using them example the reflective journal. In addition, the video recording was not by a professional due to time constraint. I had to ask a learner to do the video recording for me. Lastly, being a novice at utilising the CoRes and PaP-eRs as a tool to collect data it was difficult for me to construct and to analyse them. The study is a self-study; therefore findings cannot be generalized to other teachers even though there might be similarities.

6.6. Recommendations

A recommendation from this study is that a proposed model for any curriculum implementation is needed for effective implementation. Results indicate that further planning for additional training and the much needed follow up must be done after completion of the training programme. For a successful implementation of a new curriculum, the providers of teacher support should help see planning differently. For example in the present study it evident that though planning was done but the extent to which it was followed was not so evident. Teachers should be encouraged to do preparations which spell out daily lesson rather than planning section by section.

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APPENDIX A – Consent Letter.

Tsakane secondary school
1980 Gaika street
Tsakane , Brakpan
1540
08 August 2007

Dear Principal

Re: request to do a research at your school

Research Project:

Evolution Of My Subject Matter Knowledge For Teaching Energy Resources And Its Uses In Grade 11

I the physical science teacher at your school; am currently studying my Masters in Science Education at the University of Witwatersrand, would like to conduct the above mentioned activity as part of my research at your school. The objective of the study is about the evolution of my subject matter knowledge for teaching energy resources and mining coal as a new topic for the new curriculum.

The study will take place during normal class lesson with the learners, which will be video recorded. Therefore , no time will be wasted during this activity. I would like to emphasise that the study is being conducted for purposes of improving the quality of learning and teaching of science in the school and that no harm will come to learners as a result of participation in this study.

I am aware that the Department of Education does not allow any research to take place during the fourth term since learners will be writing examinations. But the topic energy resources and mining of coal is done in that term because it encompasses almost all the work done during the other three terms. The parents will be informed and have to sign the consent forms. Learners also will sign consent forms.

Yours in education

Miss M.K. Khumalo _____

APPENDIX A – Consent Letter.

Tsakane secondary school
1980 Gaika street
Tsakane , Brakpan
1540
08 August 2007

Dear Parent/Guardian

Research Project:

Evolution Of My Subject Matter Knowledge For Teaching Energy Resources And Its Uses In Grade 11

I the physical science teacher of the above mentioned school; am currently studying my Masters in Science Education at the University of Witwatersrand, would like to conduct the above mentioned activity as part of my research with your child/ward. The objective of the study is about the evolution of my subject matter knowledge for teaching energy resources and mining of coal as a new topic for the new curriculum.

The study wiil take place during normal class lesson with the learners, which will be video recorded. Therefore , no time will be wasted during this activity. I would like to emphasise that the study is being conducted for purposes of improving the quality of learning and teaching of science in the school and that no harm will come to your child/ward as a result of participation in this study.

I have attached two consent forms to this letter. They are to be completed by the learner and the parent/guardian.

Yours in education
Miss Maureen Khumalo

_____

APPENDIX A - Consent Letter.

Tsakane secondary school
1980 Gaika street
Tsakane , Brakpan
1540
08 August 2007

Informed Consent Form: **Parent/Guardian**

Research Project

Evolution Of My Subject Matter Knowledge For Teaching Energy Resources And Its Uses In Grade 11

I _____, parent/guardian of my child/ward _____ consent to her/him participating in the study conducted by Miss M. K. Khumalo of Tsakane secondary School. I realize that no harm will come to my child/ward as a result of participation in this study, and that the study is being conducted for the purpose of improving the learning and teaching of science in the school.

I allow my child/ward to participate voluntarily and understand that s/he may withdraw from the study at any time.

I allow my child/ward to be audio taped	YES	NO
	YES	NO
I allow my child/ward to be video taped	YES	NO

Verbatim quotes from my child/ward may be used in the research report, but they will be reported so that her/his identity is anonymous. Any specific individuals my child/ward refers to will be given pseudonyms. I understand that the results of the study may be published, but my child/ward's identity will be anonymous.

Name: _____

Signature: _____

Date: _____

Tsakane secondary school
1980 Gaika street
Tsakane , Brakpan
1540
08 August 2007

Informed Consent Form: Learner

Research Project

Evolution Of My Subject Matter Knowledge For Teaching Energy Resources And Its Uses In Grade 11

I _____, grade11 physical science learner agree to participate in the study conducted by Mrs M.K. Khumalo of Tsakane secondary School. I realise that no harm will happen to me as a result of participation in this study, and that the study is being conducted for the purpose of improving the learning and teaching of science in the school.

I agree to participate voluntarily and understand that I may withdraw from the study at any time.

	YES	NO
I agree to be video taped	YES	NO
I agree to be audio taped	YES	NO

Verbatim quotes from me may be used in the research report, but they will be reported so that my identity is anonymous. Any specific individuals I may refer to will be given pseudonyms. I understand that the results of the study may be published, but my identity will be anonymous.

Name: _____

Signature: _____

Date: _____

APPENDIX B - Ethics Letter.

Wits School of Education

27 St Andrews Road, Parktown, Johannesburg, 2193 • Private Bag 3, Wits 2050, South Africa
Tel: +27 11 717-3007 • Fax: +27 11 717-3009 • E-mail: enquiries@educ.wits.ac.za • Website: www.wits.ac.za

STUDENT NUMBER: 0419703M
Protocol: 2007ECE57

Ms.M Khumalo
14159 September Street
Kwa Thema ext 2
SPRINGS
1575

Application for Ethics Clearance: Master of Science

The Ethics Committee in Education of the Faculty of Humanities, acting on behalf of the senate has considered your application for ethics clearance for your proposal entitled:

Evolution of my subject matter for teaching energy resources and its uses in Gr. 11

The following comments were made:

- There is no subject information sheet and the covering letter to parents/guardians fails to sufficiently inform parents what the study is all about and exactly how it will benefit the teacher and the learner. There is no mention of confidentiality and the covering letter is vague and ill-constructed. The same goes for the letter that starts "Dear Sir" - who is this person(s) or is it the GDE?
- The aims of the research and research questions on page 4 of the Research Proposal should be used to clarify what the study is about in the information sheet and consent letters and forms.
- The Informed Consent Form to parents/guardians (is this the right form?) must be rephrased to eliminate confusion (i.e. the study is being conducted to improve teacher practice, not parent practice!). Most of the sentences in the 2nd paragraph don't make sense and should be reformulated. Student needs to explain how she will guarantee anonymity even though research results may be published.
- The subject heading of this form does not square with the title of the project.
- Throughout, attention must be given to making sure that every sentence is clear and understandable. Supervisory editing is strongly recommended.
- **Research Proposal:**

It is not clear whether the teacher wants to

a) Increase her content knowledge or pedagogical content knowledge

b) Improve her teaching strategies in a unit that she admits not knowing much about, or

c) A combination of a, and b.

- Chemical systems are not a new invention (p2)!
- There are referencing discrepancies between documents issued by the DoE (p.2) and the NCS.

- Significant editing is needed.

Recommendation:

Cleared after resubmission

Yours sincerely

Matsie Mabeta
Wits School of Education

Cc Supervisor: Prof. M Rollnick & Ms. M Nakedi (via email)

Appendix C- Lesson Plans.

Learner's guide.
Lesson 1
Activity one: (Group Activity) (10minutes)

In groups of eight learners discuss the following questions

1. When you drive in a car, bus or taxi where does the energy, which causes the wheel to turn come from?
   _____
   _____
   _____
   _____
2. Give three different ways of living in the olden days that used energy_____
   _____
   _____
   _____
3. List six sources of energy
   _____
   _____
   _____
   _____
4. Classify your energy sources as renewable resources and non-renewable resources. In one sentence explain why do you classify others as renewable and others as non-renewable resources?

RENEWABLE RESOURCES	NON-RENEWABLE ENERGY RESOURCES.

_____
_____
_____

5. In your opinion, what do you think will happen if our energy resources are used up?
   _____
   _____
   _____
6. What is sustainable development?
   _____
   _____
   _____

Activity two. (LO1: AS1)

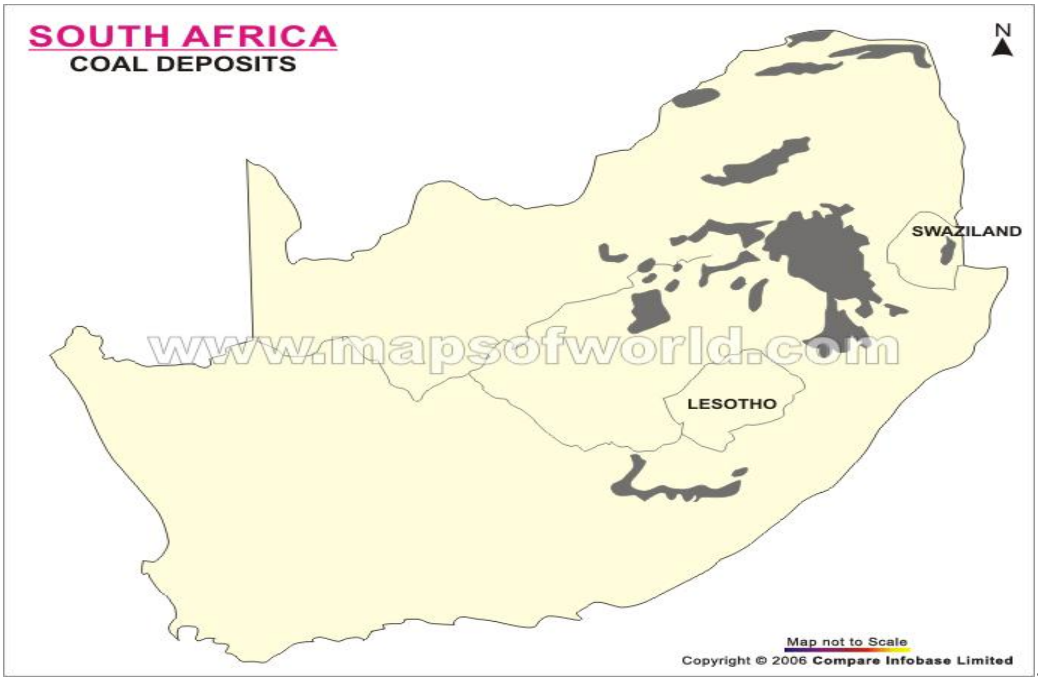
1. Electricity is generated using different types of fuels. Of all electricity used in South Africa in 2004;

- 70% came from coal power stations
- 20% come from oil power stations
- 8% came from nuclear power stations.
- 2% came from hydroelectric power stations.

1.1 Present the information in a form of a pie chart.

1.2 Why is a pie chart an effective way to present this information?

2. Use the map and the diagram to answer the following questions



Questions.

2.1.Name six fields where coal is mined?

_____

_____

2.2.What is the coal from the Witbank coalfields used for?

_____

_____

2.3.Local power stations coals have high ash content (20%) while export coals have low ash content (7%). How can you get these different coals in the same

coalfields?_____

_____

Lesson 2;
Activity one. (30 minutes)

1.Consider all the alternative renewable energy sources. Select one that would be particularly suitable for this area in which you live. Discuss the various options in your groups before making your choice. Write a letter to the Minister of energy Affairs to state and motivate your choice.

2. Copy and complete the following.

Fuel source	Energy transformation when fuel is used to produce energy.
1. Coal	
2. Biomass	
3. Wind	
4. Sun	
5. Water.	

HOME ACTIVITY

Read the following paragraph and answer the following questions.

FOSSIL FUELS

The most commonly used fuels are coal, oil and natural gases and together they provide more than three quarters of the world's energy. Fossils fuels are so called because they are formed from the remains of dead plants and animals that have been buried for millions of years. How does this fuel provide us with fuel? The bodies of plants and animals are mainly made of a compound that consists of carbon, nitrogen and oxygen (so called organic compounds). However, hundreds of millions of years ago, when the earth was in the process of cooling down, there were many more earthquakes, volcanoes and floods than there are now. This meant that when some plants and animals died, instead of rotting away completely as they reacted with oxygen, they were covered with mud or lava from volcanoes and were sealed off from reacting with the air in the usual way.

Over millions of years because of the action of bacteria, and the pressure and heat of the earth on top of them, these dead creatures turned into coal (which formed from plants and animals that lived on the land) or oil and gas (which formed mainly from plants and animals that lived in the sea). When they are burnt, carbon, hydrogen and oxygen from which they are made is at last released to combine with oxygen to form carbon dioxide, water and energy. Energy is released because combustion or burning (which is really just the reaction between a substance and oxygen) is an exothermic process. The reaction can be illustrated like this:

Organic compound (containing carbon, hydrogen, oxygen) + Oxygen ⟶
carbon dioxide + water +energy

Questions

1. Where does the energy in fossils fuels come from?
   Using the information given above, draw a flow chart that shows clearly that the energy released in burning fossils fuels comes originally from the sun.
2. Draw a flow diagram to show how coal is formed.

Lesson 3:

<u>Activity one</u>. (LO1: AS1&2) (LO2: AS3)

The following products are formed when coal is burned in a power plant.

Substance produced.	% By mass
Carbon dioxide	66
Hydrogen	3
Nitrogen	1
Sulfur dioxide	3
Water	11
Ash	16

Use the information to answer the following questions on your own.

1.Use a compass and protector to draw a pie chart representing the figures shown in the table above. Label your pie chart clearly and give it a suitable heading.

2.What good effects does the use of coal have on your life?

_____
_____
_____
_____
_____
_____

3. What bad effects does the use of coal have on your life?

4. How can we overcome the bad effects and how will this influence the good effects?

4. Coal is the main source of electrical energy in SA, what are the possible negative impacts of this on the South African environment?

Lesson 4:

Activity two. (Role-play) (LO 3, AS 2,3)

The Big Debate in Goldville

1. Read the background information.
2. Join one of the five interest groups, or the town council (Group 6) that will debate the future of Goldville Mine.
3. Each group presents their points of view on this issue to the town council. A class debate follows.
4. Based on the arguments that they have heard the town council of Goldville will make a decision.

Background information.

Goldville is a town that prospered in the early 1900s when gold was discovered there**.** The mine in Goldville, Goldville mines Ltd, was one of the most in South Africa. People rushed to Goldville and established good infrastructure and facilities. However, in the 1970's the mine had to be closed because it no longer economically viable.

A few years later after the closure of the mine, a young boy fell down the abandoned mine shaft and died. The community of Goldville and nearby townships becomes concerned about the safety risk that the old mine presented. The problem was solved when the town council decided to buy the old mine from the mining company. The council set up an entertainment area called the Goldville Theme Park. Many of the Goldville's previously unemployed people were given jobs. In the Theme park tourists can go down the mine to see how gold used to be mined. There is a restaurant where people can eat the type of food that the miners ate. A jewellery shop sells gold products. The young at heart can enjoy rides on a roller-coaster and a train.

A few weeks ago a company, MicroGold Ltd, approached the town council. The company wants to buy the old mine. It wants to use modern technology, such as cyanide heap leaching, to recover the gold that is left in the mine dumps. Some people in the town are worried about this development, while others welcome it. One thing is clear: if MicroGold Ltd is allowed to buy the mine the theme park will have to be closed down. The following five interest groups will present their viewpoints to the town council of Goldville (the sixth group)

- Group 1. The Goldville Tourism Board
- Group 2. The chamber of Commerce
- Group 3. The Friends of Goldville.
- Group 4. Citizens for Economic Growth
- Group 5. MicroGold Ltd.
- Group 6. Town Council of Goldville.

Group 1. Mr/Ms Ndwandwe from The Goldville Tourism Board

The Tourism board promotes Goldville as a tourist attraction in South Africa and overseas. They are opposed to MicroGold's proposal. Almost 60 % of the local residents are employed by the theme park. Tourism brings in a lot of money.

Group 2. Mr/Ms Mahlangu from The chamber of Commerce

The people in this group are business people and they are divided. Those who might benefit from the re-opening of the mine, e.g. car dealers, real estates agents and super-markets, support MicroGold's proposal. But the members of the tourism industry, e.g. owners of hotels, greenhouses and restaurants are opposed to the proposal.

Group 3. Mr/Ms Mofokeng from "The Friends of Goldville".

This is an association that wants to see the historic heritage and way of life preserved. They feel that Goldville has a proud history that should be enjoyed by all South Africans.. They also believe that mining would bring environment pollution, increased crime and other problems.

Group 4. Mr/Ms Smith from "Citizens for Economic Growth"

These young professionals are in favour of the reopening of the mine. They want the opportunity to earn a better income. They also feel that the re-opening of the mine will boost Goldville's economy. With a better economy, the infrastructure will improve and new business opportunity will emerge.

Group 5. Mr/Ms Naidoo from MicroGold Ltd.

The mining company is prepared to employ most of the people currently employed by the theme park. Unfortunately, they do not have a very good environmental track record. A few years ago they were fined when a large amount of cyanide leached into a river, due to the company negligence.

Group 6. Mr/Ms Khanyile Mayor of the Town of Goldville

The town council of Goldville listens to the opening statements of all five interest groups, and facilitates the debate between them. The Town council has to decide what would serve Goldville best- that is, to sell the mine to MicroGold Ltd or to keep the theme park open.

The activity will assessed using the following rubric.

Grade. _____

Learners Name: _____

RUBRIC: ASSESSMENT OF THE LEARNER'S ABILITY TO MAKE VERBAL/ ORAL PRESENTATIONS
LO: 1 AS: 4: Communicating and presenting information and scientific arguments
LO: 3 AS: 3

Criteria	**Description of level of achievement**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Body of presentation, structured and coherent, well explained, factually correct and interesting	Little evidence of performance	Unstructured/ muddled/ no logical flow of ideas, full of mistakes	Structure could be improved, often not a good flow of ideas, a number of mistakes	Acceptable structure but ideas not always conceptualised, flow not always logical, a few mistakes	Acceptable structure and flow, hardly any mistakes	Good structure and flow, no mistakes	Exceptional ly coherent, clear and to the point, well structured, no mistakes
Good summary, highlighting key points, shows the 'big picture'	Little evidence of performance	Attempts to do summary	Summary is too short, does not justice to the presentation, no big picture' view	Summary incomplete, but does give some overview of the topic	Summary too long, gives tedious facts, audience might have difficulty in seeing the 'big picture'	An adequate summary highlighting key points	A very good summary, highlighting key points, gives the 'big picture'
Effective support materials linked to content	Little evidence of performance	Bring some support materials	Brings support material, but does not use it	Support material is not effective, e.g. posters too small, not well integrated, an 'add-on'	Support material is effective, but could be better used/integrated into the presentation	Good, well-planned support material, well integrated into the presentation	Exceptional, effective support materials linked to content, well used during the presentation , adding value
Capture audience interest, worthwhile effort, and very enthusiastic	Little evidence of performance	Makes little effort and does not show enthusiasm, effort lacks fun of impact	Does not show enthusiasms, catches the audience's interest only once or twice	Shows interest and captures audience's interest at times, but could put more effort into the presentation	Plans the presentation well, and captures a large percentage of the audience's interest most of the time	Enthusiastic, gives an interesting presentation that captures audience's interest	Exceptional and fun, worthwhile, enthusiastic effort, stimulates interest
Responses to questions	Little evidence of performance	Does not provide and opportunity for audience to ask questions	Provides an opportunity for questions to be asked, but does not provide answers	Cannot answer all the questions, lacks knowledge and understanding	Can answer only recall questions	Answers questions satisfactory	Answers higher orders questions well, shows good understandi ng
Decision made and supportive motivation	Either a decision or motivation	A decision and 1 supportive motivation	A decision and 2 motivation but only 2 supportive	A decision and 3 motivation but only 1 supportive	A decision and 2 supportive motivation	A decision and 3 motivation but only 2 supportive	A decision and 3 supportive motivation

GRADE 11. **CHEMICAL SYSTEMS.**

TEACHERS GUIDE.

LESSON ONE.

Lesson topic. Introduction to renewable and non – renewable resources.

INTRODUCTION TO ENERGY RESOURCES AND ITS USES.

Key Concepts.
Renewable. Non-renewable, fossils fuels and environmental impact.

Unit Objectives.
At the lesson learners should:

- Distinguish between renewable and non-renewable resources.
- Draw a flow chart showing how coal is formed.
- Understand why the need for fuel has increased.
- Understands the problems with energy resources.

Basic content.

Introduction.
Most energy that we use originally comes from the sun. The sun is 150 million kilometers away from Earth. Nuclear reactions in the sun produce vast amount of energy that radiate out into space. When sunrays fall on green leaves of plants, chlorophyll (green pigment) in the leaves absorbs the energy and uses it to convert water and carbon dioxide into glucose. The process is called photosynthesis. During photosynthesis the following reaction takes place.

Carbon dioxide + water $\longrightarrow$ hydrocarbons (glucose) + oxygen.

These glucose molecules combine to form many types of molecules, which form part of the building blocks of living organisms.

Energy resources

Energy resources are classified as either renewable or non-renewable. Examples of renewable energy resources are solar energy, biomass energy, water energy, ocean energy, wind energy, geothermal energy and wave energy. Nuclear fuels and fossil fuels are regarded as non-renewable resources.

Non- renewable resources

Fossil fuels are non-renewable energy resources. Oil, gas and coal are known as fossils fuels because they are formed from the fossils remains plants and animals. These remains have been compressed between layers of earth and in rocks in the ocean during thousands of years. Over time this organic matter was converted to oil, gas and coal by bacterial decay and pressure.

COAL FOR ENERGY

The formation of coal

Coal is what is known as a fossil fuel. A fossil fuel is a hydrocarbon that has been formed from organic material such as the remains of plants and animals. When plants and animals decompose, they leave behind organic remains that accumulate and become compacted over millions of years under sedimentary rock. Over time, the heat and pressure in these parts of the earth's crust also increases, and coal is formed. When coal is burned, a large amount of heat energy is released, which is used to produce electricity. Oil is also a fossil fuel and is formed in a similar way.

Fossil Fuel
A fossil fuel is a hydrocarbon that is formed from the fossilised remains of dead plants and animals that have been under conditions of intense heat and pressure for millions of years.

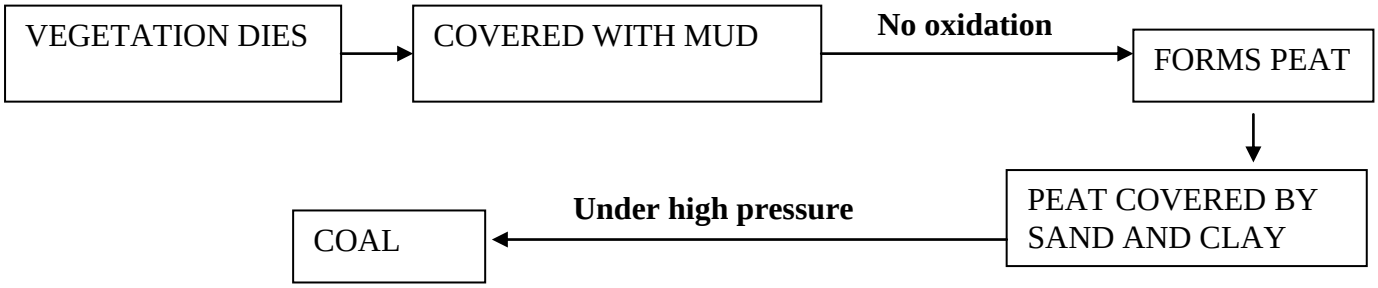


Figure1:*Flow diagram*- (how coal is formed)

The uses of coal

Although in South Africa, the main use of coal is to produce electricity, it can also be used for other purposes.

- **Electricity**

In order to generate electricity, solid coal must be crushed and then burned in a furnace with a boiler. A lot of steam is produced and this is used to spin turbines, which then generate electricity. Coal is South Africa's most available energy resource. It is used to produce about 74% of South Africa's electricity. The following shows the energy conversion in a coal-fired power station to produce electricity.
Chemical energy ⟶ Mechanical energy ⟶ Electrical energy

- **Gasification**

If coal is broken down and subjected to very high temperatures and pressures, it forms a synthesis gas, which is a mix of carbon dioxide and hydrogen gases. This is very important in the chemical industry.

- **Liquid fuels**

Coal can also be changed into liquid fuels like petrol and diesel using the Fischer-Tropsch process. In fact, South Africa is one of the leaders in this technology.The only problem is that producing liquid fuels from coal, rather than refining petroleum that has been drilled, releases much greater amounts of carbon dioxide into the atmosphere, and this contributes further towards global warming.

Our fossils fuels reserves are limited and an increase use of fossil fuel is causing pollution. To have enough energy resources in the future and reduce damages to the environment, we will have to look for alternative energy resources.

SOLUTIONS TO ACTIVITIES

Lesson one:

Activity one:

1. It comes from coal, which is used to make petrol.
2. Cooking etc.
3. coal, wind, solar, biomass, wave energy
4.

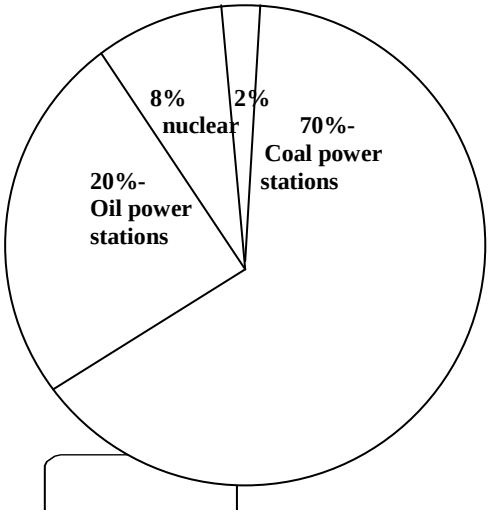
NON- RENEWABLE RESOURCES	RENEWABLE ENERGY RESOURCES.
coal	wind,
oil	solar,
gas	biomass,
	wave energy
	hydroelectric

- NON-renewable energy resources – referred to as non-renewable because once used up, it cannot simple be produced again.

5. It is converted to other forms of energy (heat and sound).
6.sustainable development- IMPROVING THE Quality of human life while living within the carrying capacity of supporting ecosystems.

Activity two:

1.1



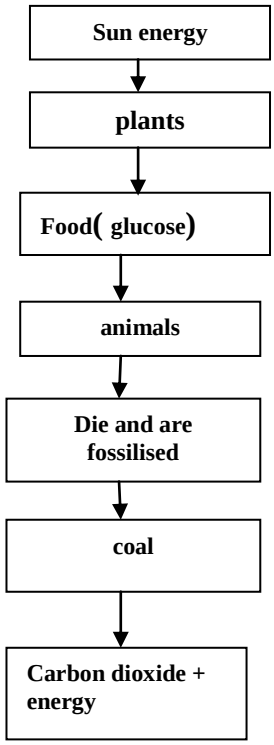
2.1 Six fields where coal is mined- Witbank, Vryheid, Vereeniging, Welkom, Klip river, Waterberg and etc.

2.2. Metallurgical, power station coal for export, for local use and local industries.

2.3. The coals have different ash content because of the way that the coal deposit was formed many millions of years ago. Mineral matter was deposited in the rotting plant material at different rates depending on the flow rate of the river systems. If the river flowed fast lots of mineral matter was deposited causing high ash content. When the river flowed slowly a small amount of mineral matter was deposited causing a low ash.

Home Activity

1.



2. Refer to figure 1 on the teacher's guide.

Lesson two:

Teacher's guide (Coal mining)

How coal is removed from the ground

Coal can be removed from the crust in a number of different ways. The most common methods used are strip mining, open cast mining and underground mining.

- **Strip mining**

Strip mining is a form of surface mining that is used when the coal reserves are very shallow. The overburden (overlying sediment) is removed so that the coal seams can be reached. These sediments are replaced once the mining is finished, and in many cases, attempts are made to rehabilitate the area.

- **Open cast mining**

Open cast mining is also a form of surface mining, but here the coal deposits are too deep to be reached using strip mining. One of the environmental impacts of open cast mining is that the overburden is dumped somewhere else away from the mine, and this leaves a huge pit in the ground.

- **Underground mining**

Underground mining is normally used when the coal seams are a much deeper, usually at a depth greater than 40 m. As with shaft mining for gold, the problem with underground mining is that it is very dangerous, and there is a very real chance that the ground could collapse during the mining if it is not supported. One way to limit the danger is to use pillar support methods, where some of the ground is left un mined so that it forms pillars to support the roof. All the other surfaces underground will be mined. Using another method called long walling, the roof is allowed to collapse as the mined-out area moves along. In South Africa, only a small percentage of coal is mined in this way.

Renewable energy resources

Energy for south Africa

Energy source	**Advantages**	**Disadvantages.**
Nuclear	• No air emission • Small volume of waste • Reliable • Very cheap to transport.	• Need high safety standards • High decomposition cost • Waste disposal expensive
Hydro electricity	• No emission • Economically competitive	• SA has few fast flowing rivers • Need constant steam of water
Biomass	• Energy source renewable	• Land need to grow crops • Technology not well developed
Solar	• Energy source free • No emission • Electricity to remote places	• Expensive • Only available when sun shines • Chemical pollution from manufacturing cells.
Wind	• Energy source free • No emissions	• Wind does not always blow • Expensive • Large numbers of turbines needed.
Geothermal	• Energy source free • Always available	No source in SA

Energy transformation when a fuel is used to produce energy

Fuel source	**Energy transformation when fuel is used to produce energy**
Coal	Chemical potential energy ⟶ heat forms steam ⟶ kinetic energy turns turbines ⟶ electrical energy generated.
Atomic nucleus	Nuclear energy ⟶ heat (steam) ⟶ kinetic energy ⟶ electrical energy
Biomass	Chemical potential energy heat— electrical energy in turbines
Wind	Kinetic energy of wind—electrical energy in turbines
Sun	Solar energy—electrical energy in circuits
Water (fresh)	Gravitational potential energy—kinetic energy—electrical energy in turbines
Water (sea)	Wave kinetic energy –gravitational potential energy – kinetic – electrical energy

Lesson three:

The environmental impacts of coal mining

There are a number of environmental impacts associated with coal mining.

- **Visual impact and landscape scars**

Coal mining leaves some very visible scars on the landscape, and destroys biodiversity (e.g. plants, animals). During strip mining and open cast mining, the visual impact is particularly bad, although this is partly reduced by rehabilitation in some cases.

- **Spontaneous combustion and atmospheric pollution**

Coal that is left in mine dumps may spontaneously combust, producing large amounts of sulfurous smoke, which contributes towards atmospheric pollution.

- **Acid formation**

Waste products from coal mining have a high concentration of sulfur compounds. When these compounds are exposed to water and oxygen, sulfuric acid is formed. If this acid washes into nearby water systems, it can cause a lot of damage to the ecosystem. Acid can also leach into soils and alter its acidity. This in turn affects what will be able to grow there.

- **Global warming**

As was discussed earlier, burning coal to generate electricity produces carbon dioxide and nitrogen oxides, which contribute towards global warming. Another gas that causes problems is methane. All coal contains methane, and deeper coal contains the most methane. As a greenhouse gas, methane is about twenty times more potent than carbon dioxide.

Solution to activities:

Activity one:

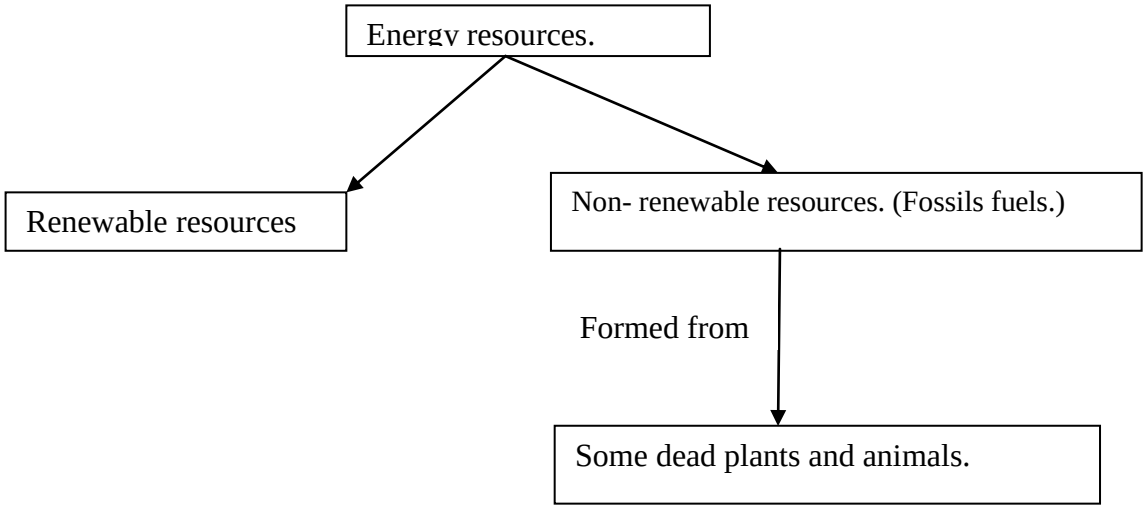
1. Pie chart
2. The commodities that I use everyday make my life comfortable e.g. petrol for transport. Coal mining also generates employment for many parents.
3. Air pollution, water pollution and destruction of top soil
4. Need to decide priorities are regarding the environment and the commodities I like. (open ended)

Lesson four: Role play refer to learners guide.

Appendix D- Researchers Diary.

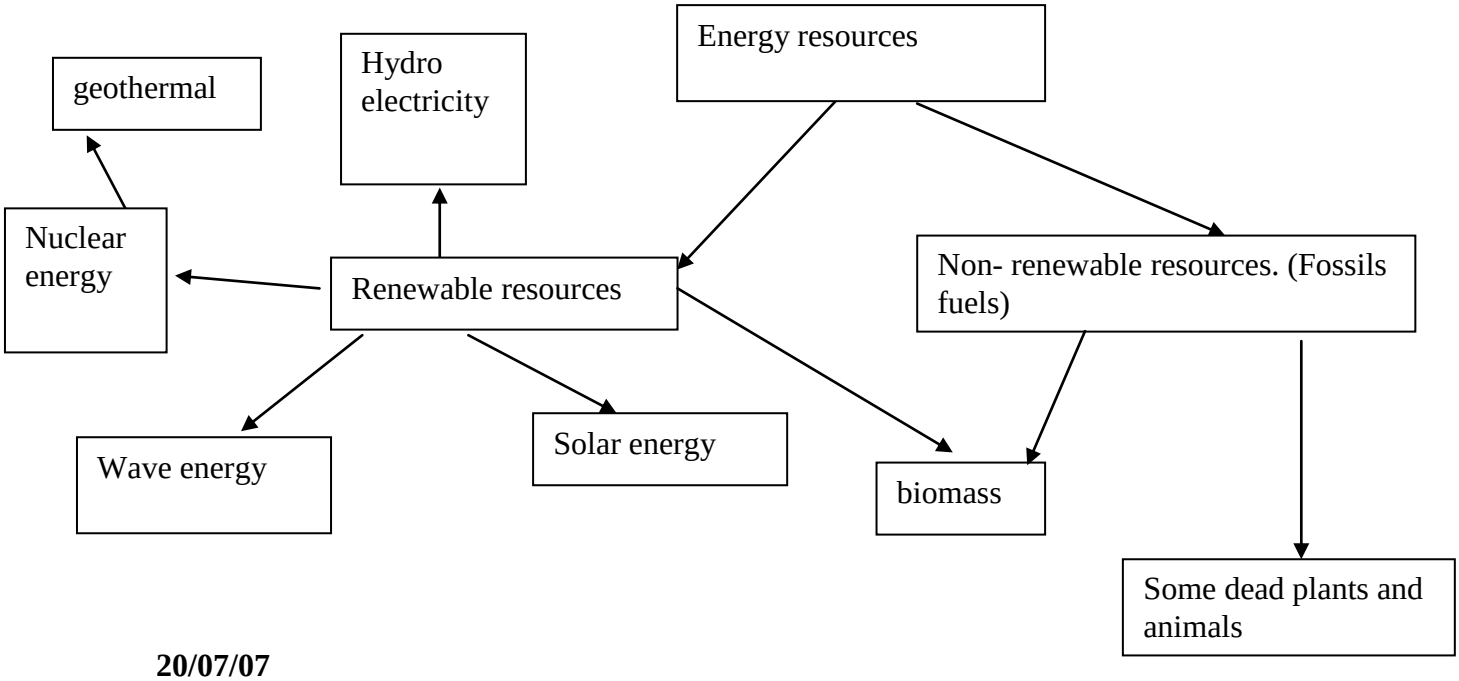
Researcher's diary

07/07/07.
It a cold day and I am a bit lazy but I took some textbooks and read the content. I have been getting nowhere with content, so I decided to go to a local library with some text books, because I thought the disturbance at home aggravate my frustrations. And understanding. some textbooks I find it hard to ignore the fact that whatever I'm dong , I'm doing it to complete my masters degree. I must say that I have been trying to read with no breakthrough. Some concepts were new and difficult to understand. Today I feel much better with some concept. I think this is because I am also using a dictionary .the concept map of what I understood about the content is as follows.



What happened	How did I feel	What did I learn	What can I change or do differently.
Read the subject matter.	I felt helpless and confused	Formation of the non-renewable resources. Difference between non-renewable and renewable resources.	Change my attitude towards geographic concepts. I must take this as a challenge and a learning curve.

09/07/07.
It a Monday afternoon and I was teaching the grade 12 the whole morning. I was tired but I felt the need to continue reading the content so that I will understand more and because I feel that I do not have enough time left to continue reading. I wanted to start with the development of lessons but I was hesitating, since I was not sure about the content. . After reading for an hour I started to feel a little confident about some of the concepts. Hence my concept map is as follows.



20/07/07

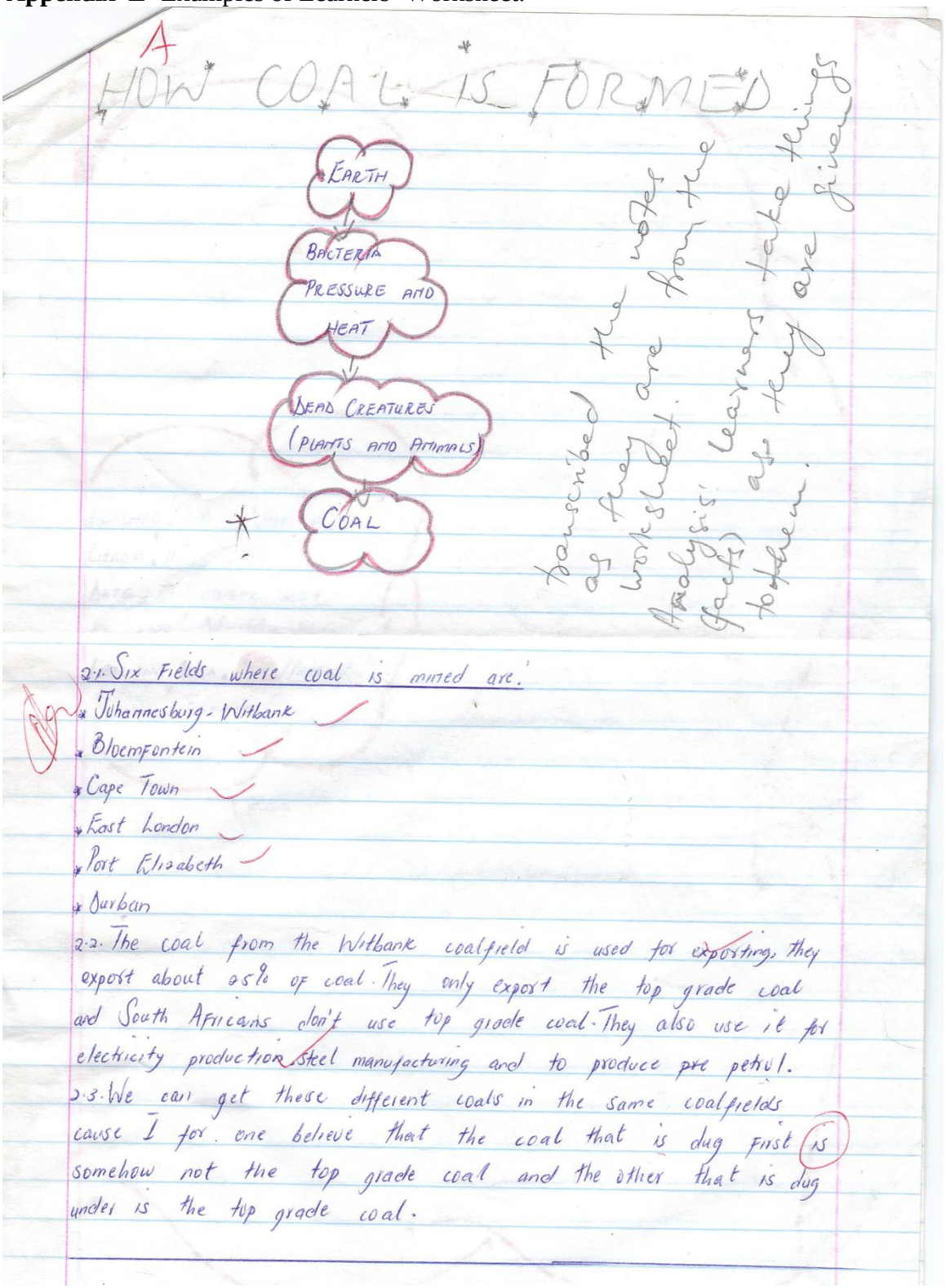
It a meeting with my collaborative team, which includes the subject expert and two other, colleagues. The environment is conducive for the meeting and we are sharing ideas.

What happened	How did I feel	What did I learn	What can I change or do differently.
Brainstorming about the big ideas.	I felt that this is too much work and what does Big ideas have to do with lesson development because to me developing lessons meant taking the content and interpret in way that is understandable to learners. Then write the sequence of your lesson. And also I felt that this is not practical at the beginning. But towards the end of the session I saw the importance of the big ideas and I saw this as a challenge to get it right.	I learnt that it important to choose the big ideas so as to know what to expect when teaching that content. Also it helps you as an educator to try and choose the best suitable method to use. Big ideas are a useful tool when developing a lesson	Use the national curriculum content as a guide to sequence the content. Change the idea of believing that its theory first and then application - I learnt that the journal can be done in any way as long as the information flow, hence I used the table below

Dates	What happened?	How do I feel about it?	What did I learn?	What can I change or do differently?

25/07	- I tried with the Big Ideas to fill the prompts at home	- I found it very difficult to do this CoRe because I have never taught the lessons yet. I felt like they are demanding a lot and I realized that it's not easy to fill the CoRe	I learnt that the CoRe help as a guide before you even start with the lesson.	I must be eager to try new things no matter how difficult they may look.
27/07	-Meeting with collaboration team -Given material from internet by our co-supervisor	- I felt a little bit relieved seeing that the material had information that I was struggling to understand	- Learnt about different types of coal - Energy liberation of the different types of coal	
13/08	- Start designing lessons using the CoRe as a guide	I felt at easy designing the first lesson.	I learnt that it becomes easy to plan when you use the CoRe , especially when preparing the learners guide.	
17/10	-at home marking learners home activity .	- Felt bad because learners shows lack of understanding either the instruction or they did not understand the difference between concept map and flow diagrams	I do not have to take it that learners can read with an understanding that I must explain the instruction to learners.	I must change with next class start by explaining the difference between flow diagram and concept map. I had to change the sequencing of lesson for the next class.
24/10	in class with learners doing the role play my first time using a role play	I was frustrated not so sure how to do the activity Spend a lot of time explaining to each what to do	Prepare learners first for such activity a day before Explain what they are suppose to do a day before	learners must use a double period for the role play I must give a least ten minutes to conclude the activity.

Appendix E- Examples of Learners' Worksheet.



A

HOW COAL IS FORMED

EARTH

BACTERIA PRESSURE AND HEAT

DEAD CREATURES (PLANTS AND ANIMALS)

COAL

transcribed the notes as they are from the worksheet. Analysis: learners take things as they are given to them.

2.1. Six Fields where coal is mined are.

- Johannesburg - Witbank
- Bloemfontein
- Cape Town
- East London
- Port Elizabeth
- Durban

2.2. The coal from the Witbank coalfield is used for exporting, they export about 25% of coal. They only export the top grade coal and South Africans don't use top grade coal. They also use it for electricity production, steel manufacturing and to produce pre petrol.

2.3. We can get these different coals in the same coalfields cause I for one believe that the coal that is dug first is somehow not the top grade coal and the other that is dug under is the top grade coal.

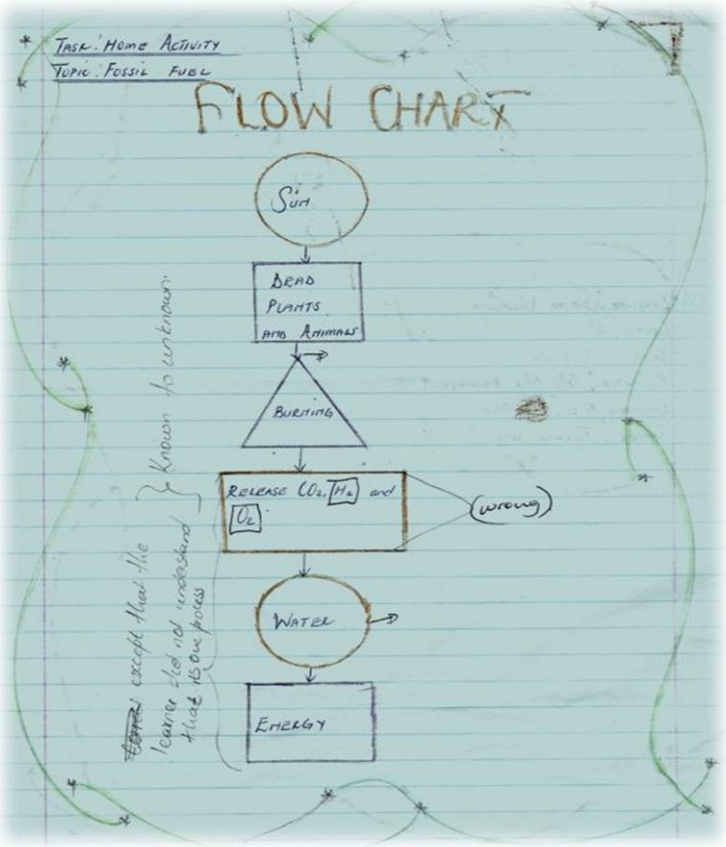
[redacted]

2.1 Six Fields where wal is mined are.

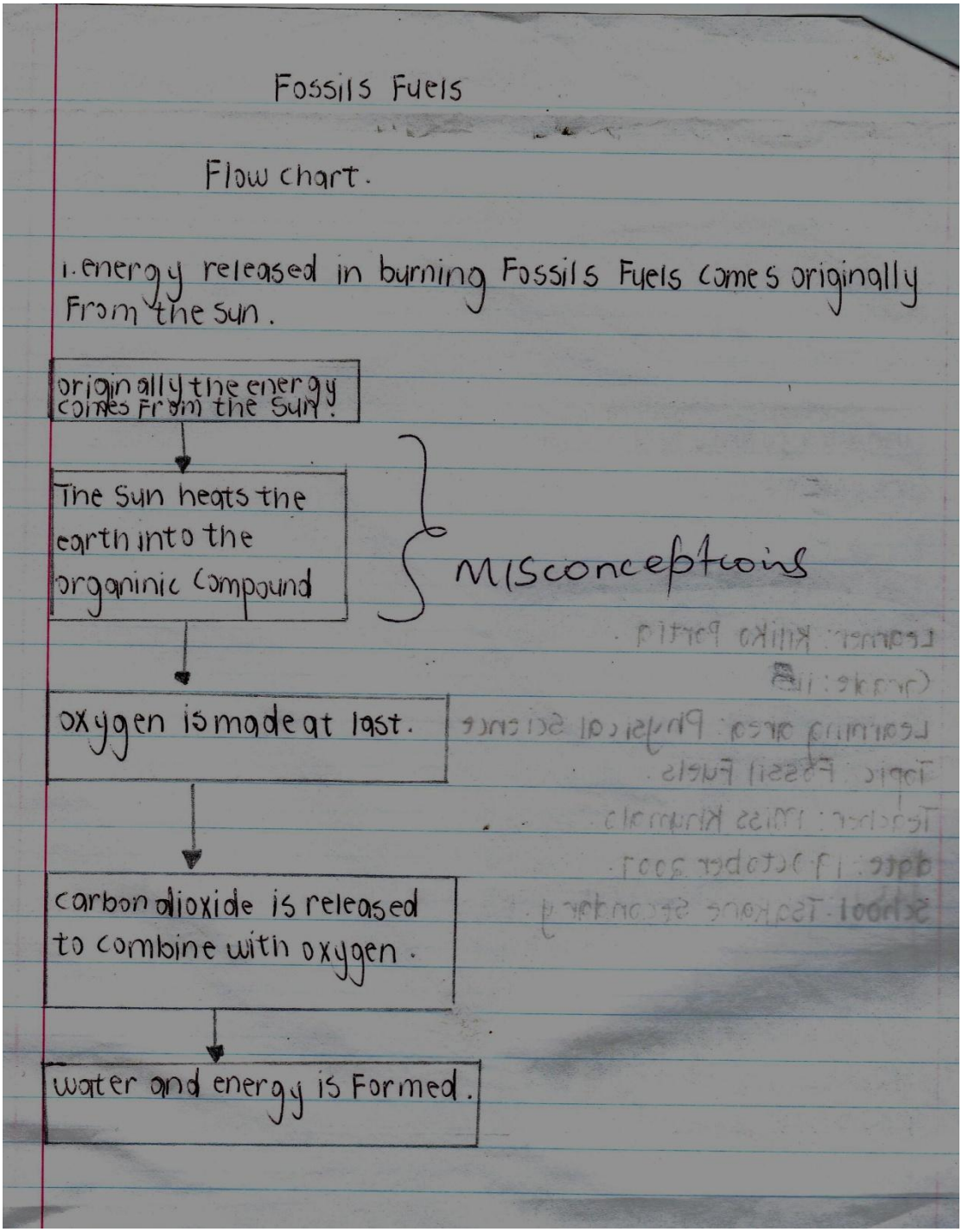
* Johannesburg - Witbank
* Bloemfontein
* Cape Town
* East London
* Port Elizabeth
* Durban

2.2 The coal from the Witbank coalfield is used for exporting, they export about 25% of coal. They only export the top grade coal and South Africans don't use top grade coal. They also use it for electricity production, steel manufacturing and to produce petrol.

2.3 We can get these different coals in the same coalfields cause I for one believe that the coal that is dug first is somehow not the top grade coal and the other that is dug under is the top grade coal

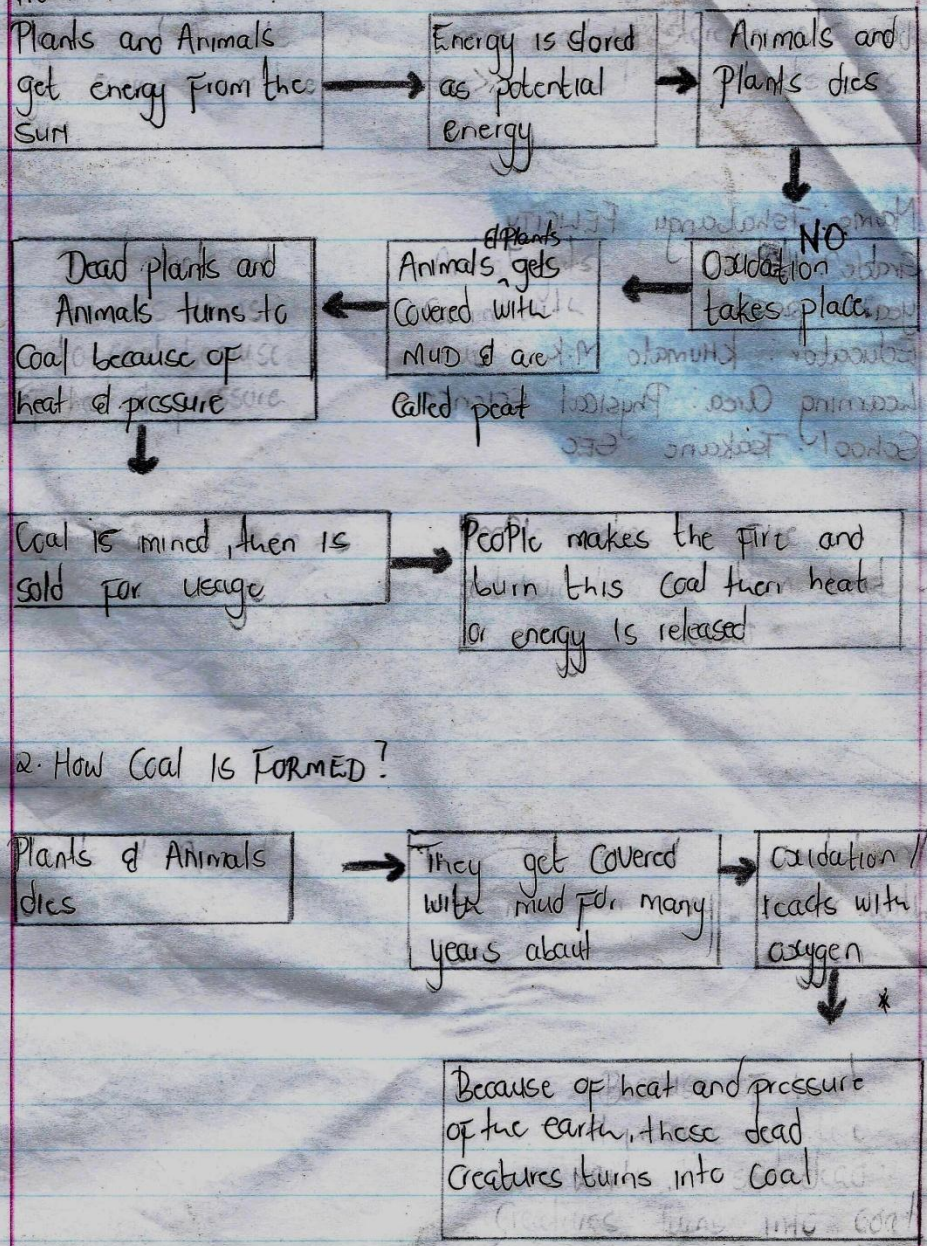


More Sample From The Second Group


Fossils Fuels
Flow chart.
1. energy released in burning Fossils Fuels comes originally From the sun.
originally the energy comes From the Sun!
The Sun heats the earth into the organinic compound
Misconceptions
oxygen is made at last.
carbon dioxide is released to combine with oxygen.
water and energy is Formed.

F.

1. Energy released in burning Fossils Fuel Comes Originally From the sun.



2. How Coal is FORMED?

Appendix F- Examples of Transcripts from the Collaboration Team.

20/07/2007.

We met with collaboration team to discuss the process of developing lessons and collecting data.

Me: Prof, I don't understand the Big Ideas, what do they have to do with lesson development.

Mrs Moloi*:* Are THE Big IDEAS JUST sentences that you can take from any textbook and use.

Chemistry expert: Big Ideas are seen as a heart of understanding the topic you must teach, they give reasons how the teacher approach a certain topic, they are not just sentences. You need to find more material on mining so that you will understand the topic better'

PhD Student: One way of documenting you reflective journal is by using a table with the following headings 'What happened, How did you fell, what did you learn and what can you change'.

Chemistry expert: We brainstorm and use your sentences to come up with Big Ideas.

27/10/2007.

Chemistry Expert: ' Maureen why did the most of your learners wrote coal is formed from dead

plants and animals in their maps'

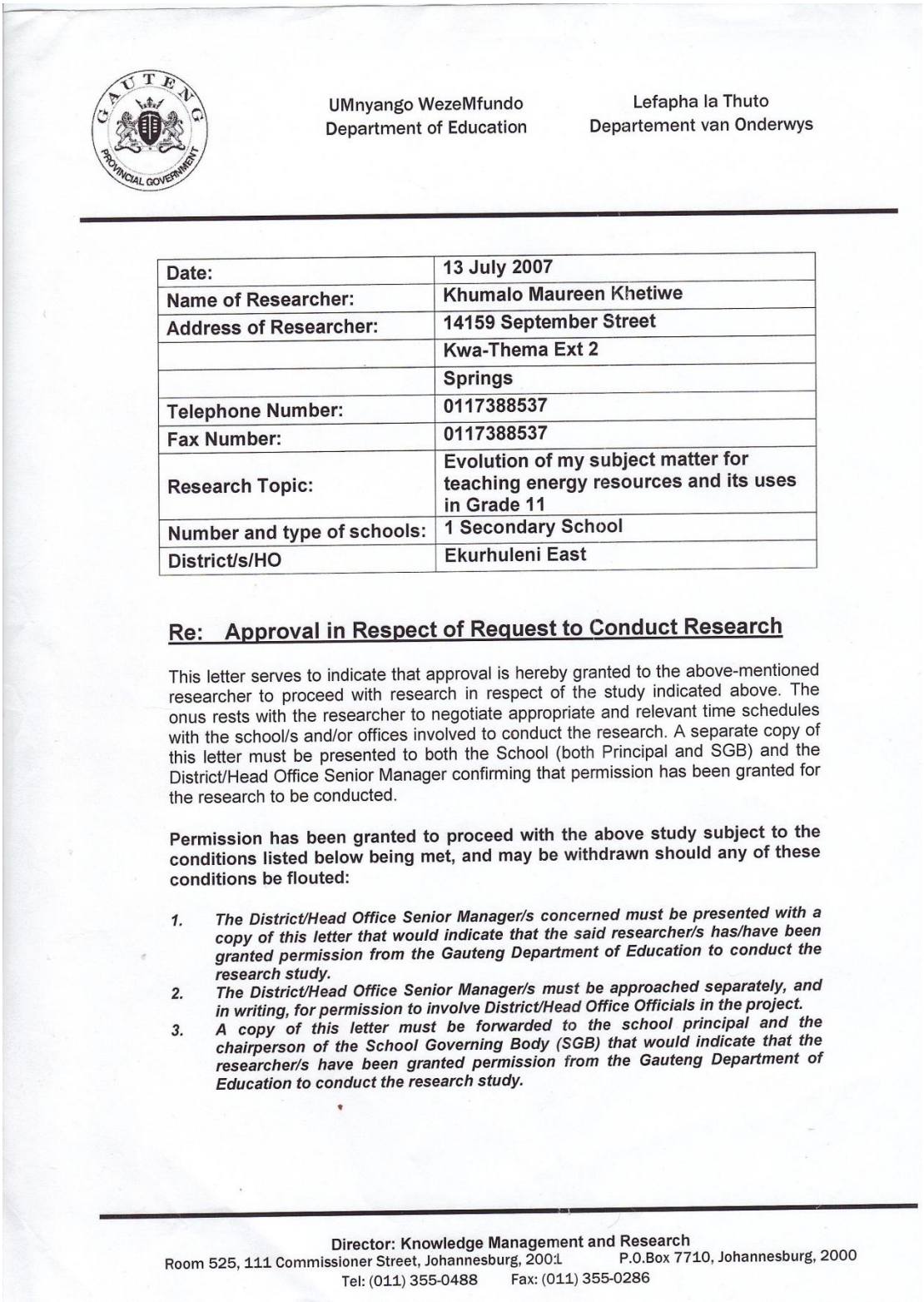
Me ; 'That is how it is explained in the textbook, why is it wrong"

Chemistry Expert: 'Yes it is wrong coal is formed from the remains of dead plants not animals'.

Mrs Moloi ' In Maureens learnesr worksheet most learners have written 'oxidation' instead of no oxidation, where did they get that idea from.

Me ; as I was watching the video I realised that on the chalkboard I wrote oxidation.

Appendix G- approval letter from department of education.



UMnyango WezeMfundo
Department of Education

Lefapha la Thuto
Departement van Onderwys

Date:	**13 July 2007**
Name of Researcher:	**Khumalo Maureen Khetiwe**
Address of Researcher:	**14159 September Street**
	Kwa-Thema Ext 2
	Springs
Telephone Number:	**0117388537**
Fax Number:	**0117388537**
Research Topic:	**Evolution of my subject matter for teaching energy resources and its uses in Grade 11**
Number and type of schools:	**1 Secondary School**
District/s/HO	**Ekurhuleni East**

Re: Approval in Respect of Request to Conduct Research

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

Permission has been granted to proceed with the above study subject to the conditions listed below being met, and may be withdrawn should any of these conditions be flouted:

1. ***The District/Head Office Senior Manager/s concerned must be presented with a copy of this letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.***
2. ***The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.***
3. ***A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s have been granted permission from the Gauteng Department of Education to conduct the research study.***

Director: Knowledge Management and Research
Room 525, 111 Commissioner Street, Johannesburg, 2001 P.O.Box 7710, Johannesburg, 2000
Tel: (011) 355-0488 Fax: (011) 355-0286

4. ***A letter / document that outlines the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.***
5. ***The Researcher will make every effort obtain the goodwill and co-operation of all the GDE officials, principals, and chairpersons of the SGBs, teachers and learners involved. Persons who offer their co-operation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.***
6. ***Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal (if at a school) and/or Senior Manager (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.***
7. ***Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year.***
8. ***Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.***
9. ***It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.***
10. ***The researcher is responsible for supplying and utilising his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.***
11. ***The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations.***
12. ***On completion of the study the researcher must supply the Senior Manager: Strategic Policy Development, Management & Research Coordination with one Hard Cover bound and one Ring bound copy of the final, approved research report. The researcher would also provide the said manager with an electronic copy of the research abstract/summary and/or annotation.***
13. ***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.***
14. ***Should the researcher have been involved with research at a school and/or a district/head office level, the Senior Manager 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

Tom Waspe
CHIEF INFORMATION OFFICER
Waspe 20/07/2007.

The contents of this letter has been read and understood by the researcher.	
Signature of Researcher:	
Date:	13-08-07