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FACING THE CHALLENGE OF LEARNING AND TEACHING GOLD MINING GRADE 11 IN THE NEW CURRICULUM: A SELF- STUDY

BY

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A Research Report submitted in partial fulfilment of the degree of

Master of Science

(Science Education)

School of Education, Faculty of Science



Supervisor

Prof. Marissa Rollnick

Declaration

I declare that this research report is my own unaided work, except as indicated in the acknowledgements, the text and the references. It is being submitted in partial fulfilment of the requirements for the degree of Master of Science at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other institute.

Signed Date

……. ……

Majabulile Ndhlovu

Abstract

The South African government that was elected in 1994 made tremendous changes in the Education system. The new government came up with the new curriculum for Basic Education (grade R- 12). The new curriculum had new topics in physical science. This made me as a teacher doubt whether I would be able to teach new topics. During my time as a student, I was not taught mining at school or college. As a result, I decided to do a self study in order to investigate how I would learn gold mining as a topic in order for me to be able to teach it to my learners. My study involved studying my own teaching practice while learning and also finding out the key things that made me understand the content knowledge involved in the topic of gold mining. The self study was done in order to ensure that I understood the content knowledge and how best to teach it to the learners. I used a collaboration team, reflective journal, group interviews classroom observation and learners' responses to collect data. The participants were my grade 11 learners and myself. My data was analysed using a PCK model, CoRes and PaPeRs. I had to learn the content knowledge and transform it to make it understandable to learners. I designed lessons using the prior knowledge of learners and integrating Physical Science and Geography. Lessons did not go as smoothly as I had expected. Learners wanted some of their existing knowledge to be included. The classroom activities depended entirely on the relationship between the teacher and learners. I carried out my study bearing in mind that implementation of the new curriculum depends not only on classroom interactions (DoE, 2002) but most importantly on the content knowledge that the teacher has and how it is transformed. Learners taught me to understand gold mining from the geographical point of view as well from the scientific point of view. From the beginning of the study they were really excited and were looking forward to new things. Using the learners' science prior knowledge helped me design lessons that allowed me to learn to be a facilitator.

Key Words: Content Knowledge, Gold mining, National Curriculum Statement, curriculum 2005, Chemical systems, Pedagogical Content Knowledge (PCK), Content Representation (CoRe), Pedagogical and Professional experience Repertoires (PaP-eRs).

Acknowledgements

Firstly, I would like to thank God for giving me the opportunity to complete this Masters degree. It is by His grace that this Masters has been completed.

I wish to thank most deeply my supervisor, ***Prof. Marissa Rollnick*** who has provided, without hesitation, and with unflagging support, constructive comments, and suggestions, all of which provided a strong backing for this Masters Research work. I would like to thank her for the support and the intellectual energy that she gave to this report and for her ability to listen with care and critique with rigour. Thank you is not enough!

I would like to thank the participants in the study for their patience and support during the process of data collection.

To my family- Thank you very much.

Dedication

This research report is dedicated to my wonderful mum, Nkuthe (RIP) who supported me and encouraged me to do my masters even when it seemed so difficult. I will always be grateful to her.

Table of Contents

Declaration ii
Abstract iii
Acknowledgements iv
Dedication v
Table of Contents vi
List of Tables x
List of Figures xi
Abbreviations xii
Chapter 1: Introduction of the Study 1
1.1 Introduction **1**
1.2 Context of the Study **1**
1.3 Rationale **3**
1.4 Problem of the Study **3**
1.5 The Aim of the Study **4**
1.6 Research Questions **4**
1.7 Conclusion **4**
Chapter 2: Theoretical Frame work and Literature Review 6
2.1 Introduction **6**
2.2 Theoretical Framework **6**
2.2.1 Pedagogical Content Knowledge (PCK) 6
2.2.2 PCK from the Perspective of Other Researchers 7
2.3 Literature Review **10**
2.3.1 Capturing and portraying PCK 10
2.4 Further Literature on PCK **11**
2.4.1 Content Knowledge 11
2.4.2 Learner's Prior Knowledge 12
2.4.3 Knowledge of Representations 14
2.4.4 Curriculum Materials and Curriculum Saliency 14

2.4.5 Assessment 15
2.5 Curriculum Implementation **15**
2.5.1 Teacher Factors 17
2.5.2 Learner Factors 18
2.5.3 School Ecology and Management 18
2.6 Conclusion 18
Chapter 3: Methodology and research methods 19
3.1 Introduction **19**
3.2 Research Design **19**
3.3 Participants **21**
3.4 Data Collection Methods **21**
3.4.1 Reflective Journal 21
3.4.2 Classroom Observations using Video Recording 22
3.4.3 Group Interviews 23
3.4.4 Collaboration Team 25
3.5 Data Collection **25**
3.6 Rigour **26**
3.6.1 Validity 27
3.6.2 Trustworthiness 27
3.7 Data Analysis **27**
3.8 Ethics **27**
3.9 Conclusion **28**
Chapter 4: CoRes and PaP-eRs 29
4.1 Introduction **29**
4.2 Construction of CoRes **29**
4.2.1 Discussion on CoRes 35
4.2.2 Conclusion on CoRes 37
4.3 Construction of PaP-eRs **38**
4.3.1 PaP-eR 1: Does a stone dissolve? 38
4.3.2 PaP-eR 2: Learners' Voices 39
4.3.3 PaP-eR 3: From Stone Age to Copper Age 42

4.3 Conclusion on PaP-eRs **44**
4.4 Conclusion **45**
Chapter 5: Development of my Pedagogical Content Knowledge 46
5.1 Introduction **46**
5.2 Data Analysis **46**
5.3 Manifestations of Teacher Knowledge **48**
5.3.1 Topic Specific Instructional Strategies 48
5.3.2 Curricular Saliency 50
5.3.3 Assessment 51
5.4 My Content Knowledge **57**
5.5 Conclusion **59**
Chapter 6: Conclusions and Recommendations 60
6.1 Introduction **60**
6.2 Overview of the Study **60**
6.3 Critical Reflection of the Study **60**
6.3.1 The Methodology 60
6.3.2 Discussion of the Findings 62
6.4 Summary of the Findings **67**
6.4.1 How do I Transform My Content Knowledge in order to Teach Gold Mining? 67
6.4.2 How does My Understanding of the Relevant Content Change as I Teach? 68
6.4.3 What are Some Challenges Influencing the Way I Learn to Teach Gold Mining? 68
6.4.4 What is the Impact of the Learners' Prior Knowledge on the Way I Teach? 68
6.5 Limitations of the Study **69**
6.6 Recommendations **70**
6.7 Directions for Future Research **70**
References 72
Appendix A – Consent letters 76
Appendix B – Ethics Letter 80
Appendix C – My Reflective Journal (Sample) 82
Appendix D – Lesson Plans 85

Appendix E – Learners' written work 100

List of Tables

Table 4.1 Combined CoRe (1 and 2)……34

Table 5.1 Teachers' knowledge domains……47

Table 5.2: Information from the three flow diagrams……...55

List of Figures

Figure 2.1 Rollnick et al.'s (2008) model of PCK……..…8

Figure2.2 The model derived from Rogan and Grayson (2003)…….....16

Figure 5.1 Rollnick et al.'s (2008) model of PCK…….46

Abbreviations

NCS	**: National Curriculum Statement**
DoE	**: Department of Education**
FET	**: Further Education and Training**
LO3	**: Learning Outcome three**
C2005	**: Curriculum 2005**
PCK	**: Pedagogical Content Knowledge**
CK	**: Content Knowledge**
CoRe	**: Content Representation**
PaP-eRs	**: Pedagogical and Professional experience Repertoires**

Chapter 1: Introduction of the Study

1.1 Introduction

The South African National Curriculum Statement (NCS) introduced new topics in Physical Science which pose challenges to teachers because they do not have the content knowledge that is required to teach the topics. Teachers are also faced with the challenges of having to adopt new teaching strategies and ways of assessing learners. As a result of these challenges, implementation of the NCS has wide ranging effects. The whole school is affected and has to adjust its way of working in order to cope with the new changes brought by a new curriculum (Rogan & Grayson, 2003). The main person that is affected by the change in the curriculum is the teacher. The challenge of teaching a new topic is that the teacher has to manage her/his learning processes, parallel to managing her learners' learning.

1.2 Context of the Study

In 1994, South Africa had a new democratically elected government. Consequently the new education department was under pressure to adopt new educational policies. In 1998, implementation of a new curriculum referred to as curriculum 2005 (C2005) began in schools in grades 1-9. In 2006, the new curriculum was extended to grade 10. In 2007, the implementation was carried out in grade 11 and in 2008 it was extended to grade 12. In all three grades (10,11and 12) there are new topics that were included as a result of the new curriculum. Upon implementation of the new curriculum, the new topics that were included raise concern because the teachers had never taught them before. Some of the teachers may have studied them at tertiary level and others have not studied these topics and they may be seeing the topics for the first time.

Chemical systems is one of the new topic in all the three grades that was introduced when the new curriculum was implemented. Under chemical systems, there is mining which is introduced in grade 11. Mining is the extraction of minerals from their ores. This process has chemistry involved in it. Mining is included in the high school curriculum to illustrate learning outcome three (LO3).

LO3 states that "a learner must be able to identify and critically evaluate scientific knowledge claims and the impact of this knowledge on the quality of socio-economic, environmental and human development" (DoE, 2006, p 10).

The mining topic was added to ensure that learners can make informed decisions about factors that affect the environment and the economy of the country. This is a good idea which was not emphasised in the old curriculum.

In addition to new topics, the new curriculum requires teachers to change from their traditional ways of teaching content to an outcomes- based approach. Studies (e.g. Rogan, 2004) have already shown that teachers had difficulty achieving the outcomes due to their lack of understanding of how to use new approaches such as group work. The difference in the introduction of the senior secondary curriculum is that teachers now know a little more about outcomes and they are used to referring to them in class and when preparing the lessons. The problem now is that some teachers do not know the content of the new topic in the new curriculum.

Rogan (2004) argues that when C2005 was implemented in South Africa, teachers were not prepared for it. They did not know what to do in the classrooms with the learners and it was not clear because there was no set curriculum. The implementation of the NCS was different to the implementation of C2005 in that the NCS, topics are clearly spelt out in a content document while C2005 does not have spelt out topics.

South African teachers rely on textbooks and what they learnt in training for content knowledge. No experts are available to help the teachers and many do not have internet access. The new NCS textbooks have shallow content. If one textbook has covered the topic the other does not have that topic. The authors wrote as if they were not given the scheme of work of each grade. Rogan and Grayson (2003) said that change is a learning process, which encompasses willingness to try out new ideas, improvise and to be exposed to uncertainty. They argue that when new practices have to survive it affects a teacher's own background, confidence, training and his/her commitment to teaching.

Elliot (1991) said that if there is a curriculum change it affects the teacher's beliefs and values. For the teacher to be prepared to learn the content all by him/herself, it takes a great amount of commitment according to Rogan and Grayson (2003).

The theme of chemical systems was included in the curriculum in order for learners to know that science is not only about school science (DoE, 2006). This topic enables learners to understand part of the nature of science and that scientists alone cannot make decisions about the world (Wellington, 2000). There are political, social and economical factors that affect the way people run the world. It can be taught using learning outcome 3 (LO3) which says that science should be relevant to technology and society (DoE, 2006). LO3 in physical science is an outcome (outcomes are not activities but are the things that should be done by learners as a result of being taught (Sanders & Nduna, 2006) that will be visible if the learner can claim an impact of science on the environment, human development and socio-economics (DoE, 2006).

1.3 Rationale

Chemical systems is a new theme and not much work has been done on it. By doing this study, I wish to help other teachers who are in the same situation as me, lecturers and the curriculum developers involved in teacher development process. It is important for me to do this study because I want to see how I develop the lesson plans and how this will help my learners. I also wish to improve my own understanding of the underlying content.

1.4 Problem of the Study

When the new curriculum was first introduced, the National Department of Education used contracted INSET providers to help with the implementation of the new curriculum. During the workshops run by the providers, not much was said in order to prepare me for teaching the new topics in the curriculum. The facilitators concentrated on general approaches to the curriculum, rather than specific content. Very little content was mentioned and no methodology whatsoever was given to the teachers. Rogan and Grayson (2003) found that when INSET was used for C2005 implementation, the providers used a "one size fits all" approach. Similarly the government INSET providers did not look at what is really needed by teachers. Possibly the time for these workshops is a limiting factor but the policy makers and INSET providers need to

address teachers' concerns since they are the ones facing the challenges of teaching the new topics. The problem I was faced with was to teach the new topic.

My greatest concern about the topic of mining was not having support from the department of education. At the same time I was expected to teach or facilitate my lessons using the new strategies of teaching. I expected the education department to assist me with the content knowledge since they are the ones that changed the curriculum I was comfortable teaching.

1.5 The Aim of the Study

A teacher is always a learner. No matter how experienced a teacher can be he/she will face challenges in any class. The challenges range from classroom discipline to learners' questions. Reflecting on one's teaching is important to see whether there is improvement or not. The objective of this study is to see how I coped as I learnt to teach the new topic of gold mining to the grade 11 class and how that will help my learners' understanding.

1.6 Research Questions

- How do I transform my content knowledge in order to teach gold mining?
- How does my understanding of the relevant content change as I teach?
- What are some challenges influencing the way I learn to teach gold mining?
- What is the impact of the learners' prior knowledge on the way I teach?

1.7 Outline of the research report

Chapter one gives an overview on the introduction to the study. This includes the rationale for the study, summarises aim and statement of the problem of the study for the study, as well as stating the research questions.

Chapter two reviews literature that is relevant to the study. Here, I selectively review literature about the pedagogical content knowledge and some literature related to the curriculum implementation.

Chapter three outlines the research design and methodology. It describes the participants, research instruments, ethical considerations and data collection process of the study. Furthermore, it addresses matters of validity and reliability, triangulation and also shows that limitations encountered in the study.

Chapter four highlights the capturing and documenting of my PCK with the use of Content Representations (Co-Res) and Pedagogical-experience Repertoires (PaP-eRs). This chapter addresses how I learned the content knowledge and how I taught my designed lessons.

Chapter five looks at the features of domains and manifestations of teacher knowledge which constitute my PCK that emerges from my teaching. Rollnick *et al.* (2008) tailored model of PCK is used.

Chapter six consolidates the findings from the analysis of the research project. It concludes the study by giving critical reflections on the study, as well as the recommendations.

Chapter 2: Theoretical Frame work and Literature Review

2.1 Introduction

This chapter focuses on the theoretical framework I chose to help me understand what will be unveiling during this study as well as the literature underlying the study. This will also help with the data analysis as I observe myself learn the new content knowledge and how I implement the new curriculum.

2.2 Theoretical Framework

2.2.1 Pedagogical Content Knowledge (PCK)

PCK was first introduced by Shulman (1986) after he and his colleagues looked at existing research on teacher education. They realised that content knowledge was no longer emphasised either in teacher education programmes or in research about teaching. Shulman (1986) argued that the hallmark of a good teacher is the ability to transform knowledge into a form that is understandable to learners. In order to transform knowledge, a teacher needs to have good content knowledge, pedagogical knowledge, curriculum knowledge and strategic knowledge (Shulman, 1986). Teachers are able to integrate what they know about teaching with their content knowledge. According to Shulman (1986, p), PCK is domain/topic specific and it is displayed by

"…the most useful forms 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"

The vital point about PCK is how pure content knowledge is transformed into teachable knowledge considering other types of knowledge such as learners' prior knowledge and many others. It is very important to contextualize the knowledge so that teachers can use what is familiar to learners. PCK also takes into consideration learners' difficulties in a particular topic, conceptions and preconceptions that learners bring to the classroom as well as their misconceptions (Shulman, 1987).

Shulman (1987) defined PCK as one of seven categories of teacher knowledge: content knowledge, general pedagogical knowledge, curriculum knowledge, pedagogical content knowledge, knowledge of learners and their characteristics, knowledge of educational context and knowledge of educational ends. Teacher knowledge is distinguished from that of the content specialist (Shulman, 1987) because a teacher must have all the seven categories of knowledge mentioned. PCK must be strong for teachers to be able to teach learners. This led to other researchers to research about different types of knowledge in PCK.

2.2.2 PCK from the Perspective of Other Researchers

Shulman's idea of PCK was interpreted differently by different researchers. Below I discuss the view about PCK that will be used in this study.

Bishop and Denley (2007) use Shulman's(1987) categories in their model of PCK, where the seven categories mentioned above are represented as different colours on a spinning top. When the top spins only one colour is visible and this shows the amalgamation of knowledge to form PCK.

Geddis and Wood (1997) used Shulman's (1987) seven categories mentioned above to develop the idea of PCK further. They divided PCK into learners' prior knowledge, subject matter representations, instructional strategies, curriculum materials and curriculum saliency. The process of transformation of content knowledge was still regarded as important as it pays attention to what teachers know in terms of content knowledge. As the transformation of knowledge occurs but teachers must be careful not lose its authenticity (Geddis, Onslow, Beynon & Oesch, 1993). This implies that teachers can modify content knowledge to make it comprehensible to learners but the original ideas should not be altered. When learners understand the original ideas, then it is a sign that transformation of knowledge has been successful. Geddis et al. (1993) did research on the contrast in teaching of isotopes by student teachers and an experienced teacher to articulate the concept of PCK. Their findings highlight the importance of knowledge of curricular saliency which the experienced teacher possessed

and the student teachers did not. Curricular saliency was seen by the ability of the experienced teacher's ability to know when and how to teach a certain topic and knowing their learners' readiness to be taught different topics.

Cochran et al. (1993) introduced PCK as pedagogical content knowing (PCKg) instead of pedagogical content knowledge. They said that acquiring this knowledge is an ongoing process because this kind of knowledge has a dynamic nature. For example teaching the same topic for many years does not mean that it is taught the same way over and over again. It depends on learners' response to the topic. Even if it is in the same year, different classes can be taught differently depending on the learners' challenges. Cochran et al. (1993) regarded PCKg as an integration of the domains of the teacher knowledge. These domains were the basis of Rollnick et al.'s (2008) model (figure 2.1 below). The model below also uses the ideas from Geddis and Wood (1997).

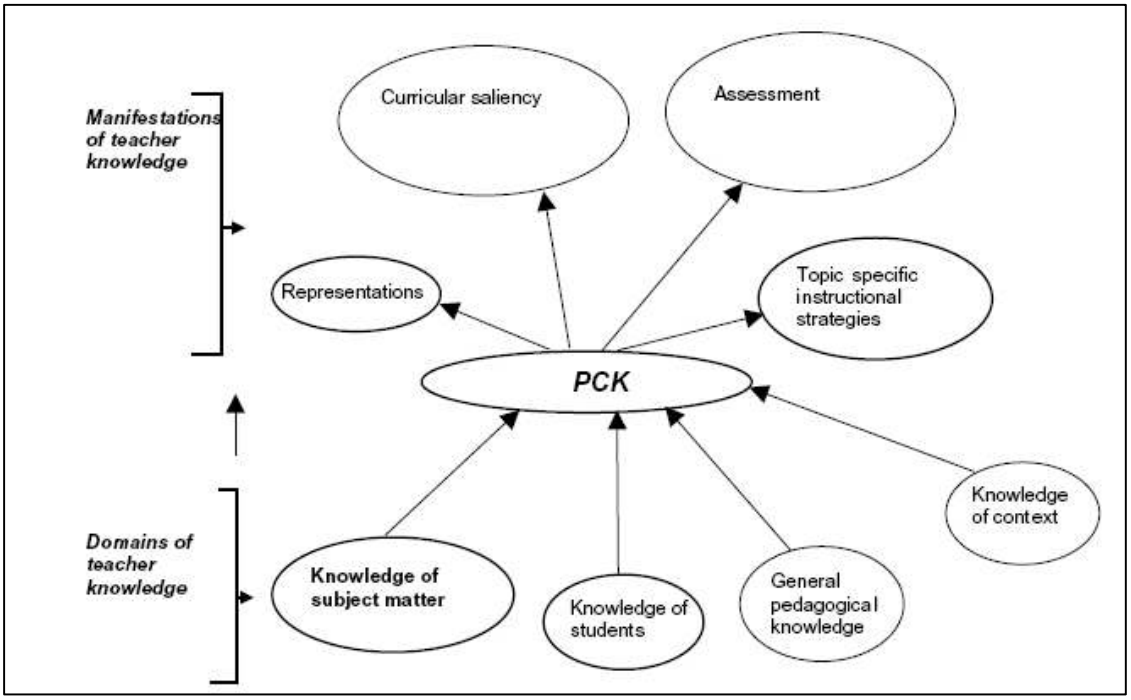


Figure 2.1 Rollnick et al.'s (2008) model of PCK

The domains of teacher knowledge describe the various types of knowledge the teacher possesses. This knowledge is only visible in what is revealed in the classroom during the lesson. What the teacher does in the classroom is referred to as the manifestations of the PCK (Rollnick et al., 2008). Rollnick, et al. (2008) stated that the domains combine to produce the PCK which is manifested in the classroom. It does not matter how the domains combine but when they combine, subject matter knowledge is transformed to produce PCK. Therefore the subject matter is a key domain. What occurs in the classroom is initially designed and planned by the teacher but conditions during the lesson may change. For example, learners may change the pacing of the lesson or even the strategy depending on circumstances. When the teacher purposefully changes something in the lesson, it is a demonstration of that teacher's PCK. The teacher is aware that learning is not taking place according to what was planned. For learning to occur, certain adjustments have to be made. The domains of the teacher knowledge also include teacher's background/history which can be his/her qualifications and beliefs. The manifestations shown in the diagram are not a complete list of manifestations and so other manifestations of PCK may be observed. This means that the top part of the diagram could be adjusted to accommodate these manifestations.

The components of the domains of teacher knowledge shown in top part of fig 2.1 are:

- **Knowledge of subject matter-** is the teacher's untransformed content knowledge (CK)
- **Knowledge of students-** refers to appreciation of learners' prior knowledge, how they learn, their interests and aspirations as well as considering their linguistic abilities.
- **General pedagogical knowledge-** is about having an understanding of what constitutes good teaching, taking into consideration the best teaching approaches in a given context, which is informed by appropriate learning theories.
- **Knowledge of context-** refers to all contextual factors influencing the teaching conditions like resources, class size, learners' socio-economic background, curriculum, conditions in the classroom and availability of time for teaching and learning. (Rollnick *et al*., 2008).

The components of manifestations of teacher knowledge are:

- **Curricular saliency**- is about "providing perspectives on the dilemma of breadth versus depth of coverage" (Geddis & Wood 1997, p. 612). Curricular saliency is in most cases influenced by the curriculum in terms of its guidelines and also by what is most likely to be in the learners' examinations or what may be useful to the learners. The other aspect that plays an important role in curricular saliency is the experience that a teacher has in teaching that particular subject (Geddis et al., 1993). Curricular saliency helps teachers to organise their lesson so that it will be easy for them to understand what comes before and after in the topic in hand (Rollnick *et al*., 2008).

- **Topic-specific instructional strategies**- refers to different approaches that teachers use like group work, whole class teaching, whole class discussion, problem-first strategy, question and answer strategy as informed by the content being taught.

- **Assessment**- may be in the form of formative or summative tasks. Formative assessment may include the type of questions asked during the lesson and also the type of questions asked in the class activity to consolidate what was learnt during the lesson.

- **Representations**- refer to the forms of representation that can be shown by the use of most powerful analogies, illustration, examples, explanations, simulations and demonstrations.

I chose Rollnick et al.'s (2008) model for this study because other models do not differentiate between the teacher knowledge domains which are internal to the teacher and the manifestations of this knowledge during the lesson. With Rollnick et al.'s (2008) model, these two are clearly distinguished.

2.3 Literature Review

2.3.1 Capturing and portraying PCK

Loughran et al. (2004) developed tools of capturing and portraying PCK. They were motivated by the fact that teacher's professional knowledge is tacit and difficult to communicate. They used

experienced teachers at the workshop to gather their data about their lessons. They came up with Content Representation (CoRe) and Pedagogical and Professional experience Repertoires (PaP-eRs) to capture and portray science teachers' PCK. The CoRe is the representation of the teacher knowledge where relevant features are used as the Big Ideas of that specific topic. The Pap-eRs are real teacher's practice that occurs in the classroom illustrating the CoRe. The different types of strategies occurring in the classroom come from the teacher's pedagogical decision and this is explained in the PaP-eRs (Loughran et al., 2004).

CoRes and PaP-eRs complement each other. The CoRe can be developed by a group of teachers or an individual. In the CoRe knowledge, learners' misconceptions, preconceptions, teaching strategies to be used during the lesson are addressed. When the teacher is presenting the lesson, all this knowledge is illustrated and sometimes the teacher can change the teaching strategies depending on what is going on in the classroom at that particular time. The decisions taken by the teacher is captured in the PaP-eRs. Both CoRes and PaP-eRs give the framework for capturing PCK because teachers can share the information (Loughran et al., 2004).

2.4 Further Literature on PCK

Here is some general literature on PCK. I reviewed literature on content knowledge, learners' prior knowledge, curriculum materials and curricular saliency.

2.4.1 Content Knowledge

The most important prerequisite for PCK is content knowledge. In order to integrate the other components of PCK, the teacher must have a good CK. The way a teacher learns CK depends on his/her beliefs, prior knowledge and misconceptions. According to Hasweh (1987), teachers with limited content knowledge carry their misconceptions over to learners, while knowledgeable teachers use their prior knowledge and exclude the superfluous concepts from the lesson. Teachers with good CK alone serve no purpose if they cannot deliver effectively (Bishop & Denley, 2007). This is what makes teachers different from subject experts because they can transform CK. For CK to be meaningful, the teacher must learn the content in a pedagogical context rather than learning content in an abstract way (Halim & Meerah, 2002). This means learning CK and transforming it to be comprehensible to learners. This is done by teachers to

simplify CK without losing the meaning. Shulman (1986, p9) argues that "to think properly about content knowledge requires going beyond knowledge of facts or concepts of the domain"

The teacher's CK helps the teacher to understand the concepts of the subject in detail as well as the correct language usage so that the learners are not confused. The teacher does not only need to know that something looks the way it does, but s/he needs to know why it looks the way it does (Shulman, 1986). He further stated that teacher's CK is the amount and organization of knowledge in the teacher's mind. The teacher must acquire more content knowledge and use more resources for effective teaching. This knowledge can be obtained from colleges and universities.

Cochran, de Ruiter and King (1993) argue that the transformation process is the continuous restructuring of CK for the purpose of teaching. They further said that when transforming the CK the teacher must interpret it to make it flexible so that it has different viewpoints to suit learners' needs and abilities. Using Shulman's (1987) steps of pedagogical reasoning, Bishop and Denley (2007) argue that transformation of knowledge is divided into critical selection, representation, selection and adaptation and tailoring. This is different when dealing with novice teachers because they struggle when they transform and represent the concepts and ideas so that they make sense to the learners (Cochran et al., 1993). However, there are experienced teachers who still struggle to transform knowledge especially if they do not consider learners' needs (Halim & Meerah, 2002). There are teachers who teach science outside their field of specialization and rely on textbooks only to learn their CK. Hasweh's (1987) research shows that these teachers follow the chapter exactly as it is from the textbooks. These teachers cannot deal with learners' questions during the lesson. Transformation of knowledge is difficult for novice teachers, as well as experienced teachers who are not in their field of specialization, for example the physics teachers who had to teach biology in Hasweh's (1987) study. Teachers who do not have a broader view of the content may give learners inappropriate and misleading examples (Halim & Meerah, 2002). It can also lead to both teachers and learners having misconceptions. Even when the teachers understand the CK by only using textbooks, the concepts are not clearly understood.

2.4.2 Learner's Prior Knowledge

Halim and Meerah (2002) argue that the key component of PCK is learners' understanding and their misconceptions of a particular topic. This will help the teacher to interpret learners' actions and ideas. It is very important for the teacher to know learners' prior knowledge before the introduction of a topic or concept. Learners come from different backgrounds and they already have some kind of knowledge from their different environments. Even the scientific knowledge they bring to class is different. Learners' prior knowledge can be affected by the context of their environment. Cochran, de Ruiter and King (1993) said that teacher must understand the learners' context as well. By context they mean attitudes, ages, motivations, developmental levels and prior knowledge. This means that the teacher must understand the learners' political, social and cultural contexts. The teacher's PCK will be far more productive if she/he uses learners' context when teaching because she/he will be able to draw information from familiar surroundings and the lesson will be meaningful to the learners. According to Halim and Meerah (2002), experienced teachers as well may be the source of problems in teaching and learning if they do not consider the learners' prior knowledge. PCK is based on a constructivist way because the learners' needs are catered for, that is learner-centred. In the constructivist theory, learners must be willing to learn therefore it is the teacher's duty to motivate them (Cochran et al., 1993).

Abimbola (1988) noted that learners should not be considered to be empty vessels because they have their own knowledge of science. Different types of knowledge should be catered for in the science classroom. Since PCK has a constructivist nature the teacher must use learners' prior knowledge as a stepping-stone for the lessons. Learners' prior knowledge should be used in the lesson and misconceptions about that particular theme must be cleared up before continuing. Misconceptions are those facts of knowledge that are not being accepted by the scientific community (Abimbola, 1988; Treagust, 1988). There are facts that need to be addressed by the teacher for effective teaching to occur. Findings from other studies were that the teacher's lack of content knowledge led to learners' misconceptions (Halim & Meerah, 2002). The participants in those studies said that learners do not understand the concepts of science due to learners' lack of interest and poor mathematical competency (Halim & Meerah,

2002). Teachers teaching outside their areas of specializations can create problems. These teachers do not have the methodology to teach the subject and only use text for preparation. Learners' questions can be very challenging and learners may ask questions which place the teacher in a tight corner. However, knowing about misconceptions is not enough; the teacher must know how to teach in a way that will change those misconceptions. The teacher must know how to represent the knowledge.

2.4.3 Knowledge of Representations

Knowledge of representations refers to the type of knowledge that has specific useful strategies to help learners understand specific scientific concepts (Halim & Meerah, 2002). The teacher cannot have special strategies of teaching a certain topic if s/he does not have the CK. This has to do with the methodology being taught in the teacher education. Cochran et al. (1993) cited Grossman's (1989) research findings that a science expert without teacher education was not well prepared to deal with learners' needs whereas a professionally qualified first year teacher would. The learners' needs require the teacher to change knowledge in such a way that it makes sense to them. Halim and Meerah (2002) said that the teachers are made aware of their teaching strategies when they deal with the learners' misconceptions. As the teachers try to answer learners' questions, their way of delivering the knowledge changes depending on what learners want to know. They will have to use different analogies, examples, illustrations, etc. After each lesson the teacher must reflect on everything especially the way the subject matter was represented. The teacher's representation is what leads to learners' better understanding and better motivation to do work in class and grasp scientific ideas. When the teacher is reflecting, s/he will find out if a particular example was the correct one to use or maybe it is the one that led to misunderstandings.

2.4.4 Curriculum Materials and Curriculum Saliency

Shulman (1986) said that teachers must know what the curriculum materials entail. They must know what is required of them to deal with a specific topic. This means that they should know the curriculum policies. From the content they have learnt they still have to strategically select certain concepts or to omit others so as not to confuse learners. This is what is referred as

curriculum saliency (Geddis & Wood, 1997). Teachers with good PCK sometimes arrange concepts differently from the curriculum materials to avoid confusing learners. Teachers are able to look at the whole curriculum or certain topics and decide to begin with concepts that will lead to better understanding of learners. PCK helps teachers to reduce any misunderstandings that can arise during the lesson.

2.4.5 Assessment

Assessments may be questions asked during the lesson or a written exercise used to consolidate the lesson (Rollnick *et al*., 2008). How learners respond to the questions or activities plays an important role to how the teacher should teach or consolidate the lesson. For effective teaching to occur teachers should address both right and wrong learners' answers (Pitjeng & Rollnick 2012). Addressing especially the wrong answers helps the teachers to find out if the previous lessons were understood or not. Without learners' responses especially individual work one gets more view on whether learners can read, understand and answer the questions correctly.

2.5 Curriculum Implementation

Curriculum implementation involves a number of things. This literature relates to the challenges encountered in implementing the new curriculum in the current study. Beeby (1966) in Rogan (2004) said that "the effect of inadequate general education on a teacher's acceptance of new practices operates at two levels intellectual and emotional" (p176). In this quote, Rogan (2004) mainly focuses on the teacher as the main deliverer of the curriculum. But Rogan and Grayson (2003) came up with a theory of curriculum implementation in developing countries and one of its components is the concept of profile of implementation which is one of three constructs namely outside support, capacity to innovate and profile of implementation shown in Fig.2.2 (Rogan & Grayson, 2003).

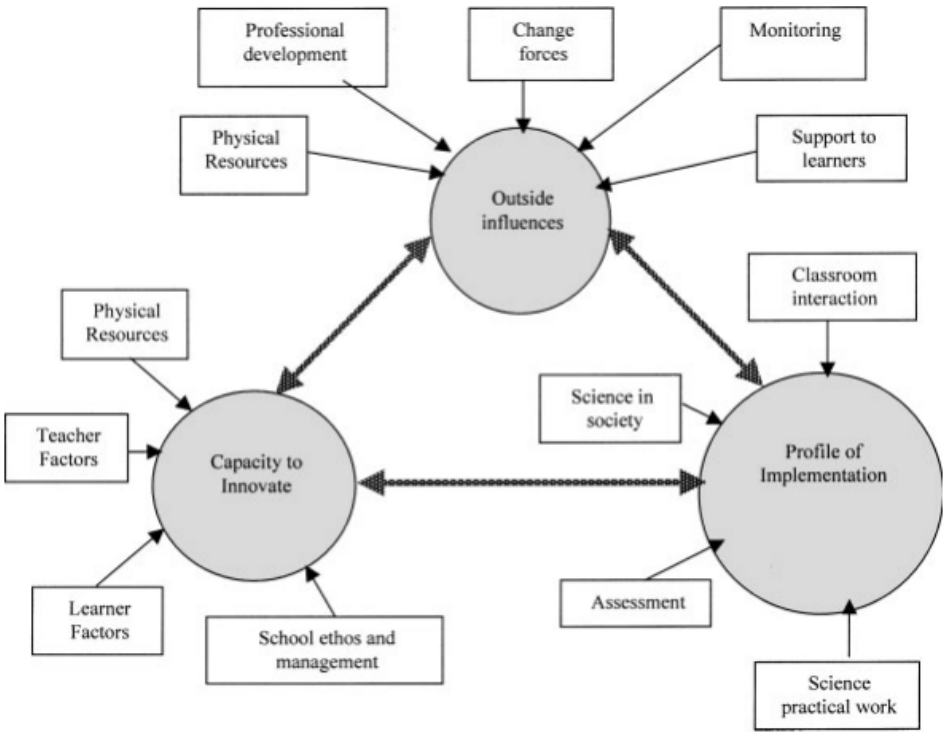


Figure2.2 The model derived from Rogan and Grayson (2003) as shown in Rogan and Aldous p314 (2005) (Rogan & Aldous, 2005).

Although teachers are the primary deliverers of curriculum, they do not start changing the curriculum themselves. There are curriculum policy makers who work for the government of that

time and decide on what should be taught in schools. Rogan and Grayson's (2003) framework starts when the curriculum materials are in the hands of the teachers. Then teachers use the profile of implementation to identify the extent in which the new curriculum is practiced in the classroom, assessments, science practical work and science in society (Rogan & Grayson, 2003). These factors are linked to capacity to innovate which has sub-constructs like teacher factors, learner factors, school ethos and management and physical resources. The last construct is the outside influence which also has sub-constructs as shown in figure 2.2. In this study I focused on the capacity to innovate as it deals with emotional and intellectual capacity of the teacher. No appropriate curriculum implementation will occur if both teachers and learners are not ready to be innovative.

2.5.1 Teacher Factors

The teacher's ability to innovate starts with the teacher factors which are teacher's identity, history (Rogan & Grayson, 2003), uncertainties and new topics (Lelliott, Mwakapenda, Doidge & du Plessis et al., 2009). A teacher can change from the old practice to a new if he/she is willing to do so and has dealt with his history and identity. Knowing who a person is the identity and knowing where one comes from is the history. These two are important when it comes to the capacity to innovate. A teacher's qualification comes in here especially when he/she has to teach a new topic (Rogan & Aldous, 2005). A new topic makes one to ask oneself if he/she has ever learnt the topic before at high school or college. If he/she has never learnt the topic, then how is he/she going to learn it and what if it is difficult to understand it and there after teach it. The higher the qualification, the better are the chances of one having learnt that specific topic. The new topics in the new curriculum really bring out uncertainties in teachers (Lelliott, et al., 2009). The way in which the teacher will learn the new content knowledge depends on the qualification of the teacher. The CK that Shulman (1986, 1987) emphasises for formation of PCK depends on the academic level and willingness of the teacher. According to Rogan and Aldous (2005) teacher factors are also about the relationship the teacher has with his/her learner that lead to better classroom interactions and a healthy environment for learning. Teachers described in Rogan and Grayson's (2003) study had problems in implementing C2005 in grade 9 classes, they did not know how to conduct group work in class. If there were problems, then there is need to

find out how the further education and training (FET) teachers deal with arising problems during implementation.

2.5.2 Learner Factors

The new curriculum in South Africa requires learner-centred education which is a constructivist way of learning. Learners' readiness plays a vital role on how they will contribute in their own learning. According to Rogan and Grayson (2003), learner factors are learners' proficiency in language of instruction, willingness to try new kinds of learning and how responsible they are for their own learning. Learners must be innovative even if they get instruction from their teachers. If teachers are not willing to be innovative or do not have ideas on how to deliver the content, this can destroy learners' capacity to be innovative. Willingness of learners also plays a role but teachers have a bigger role to play in terms of making themselves innovative as well as their learners.

2.5.3 School Ecology and Management

The schools with good management and a supportive system tend to implement the curriculum in a positive way (Lelliott et al., 2003). Teachers need to be supported by those superior to them when faced with challenges. The whole notion of working together passes on to learners and the culture of the learning becomes more evident. It does not necessarily have to be the staff willing to be innovative but other teachers learn from others. It is possible to have a teacher who can innovate in a dysfunctional school although the conditions will be very stressful. This time it was due the whole country changing the curriculum so all school were forced to implement. According to Rogan and Aldous (2005) the cohesion of good school management and all the stakeholders in education lead to professional development and better curriculum implementation. Learners are able to observe team work from all the stakeholders and take no chances in wasting their people's time.

2.6 Conclusion

In this chapter I outlined the theoretical framework and literature review I will use in this study, which were PCK and the curriculum implementation. It is experienced teachers that have PCK, but it is the PCK of the topics they have taught before. I am an experienced teacher but I have not taught gold mining before. This poses a challenge to me as I lack both CK and PCK of gold

mining. I am forced by the implementation of the new curriculum to teach this new topic. I must find ways of facing this challenge and have techniques to deal with this situation if I am confronted with it again.

The next chapter is about the research methodology and the methods.

Chapter 3: Methodology and research methods

3.1 Introduction

The previous chapter dealt with PCK and theories related to curriculum change as well as literature related to other aspects of this study. This chapter outlines methodology and research methods that were employed during the study. I will discuss the sample used and the challenges that arose during the study.

3.2 Research Design

Research is a systematic way in which an inquiry is done in order to understand better a certain situation or context. There are different approaches to research. Other researchers use either quantitative or qualitative or they can use both approaches in the same research, known as mixed methods. These approaches distinguish the way in which the nature of knowledge is perceived. The quantitative researchers believe the knowledge comes from the facts, and it is objective. Whilst the qualitative researchers believe the knowledge comes from multiple realities, which can be based on the feelings, fears and the participants' environment among others. Qualitative research is thus subjective. This is about how the researcher understands the world and the ultimate purpose of his/her research. Quantitative or qualitative approaches assist the researcher with the research methods on how data are collected and analysed, as well as the type of generalizations derived from data. Quantitative researchers establish relationships and explain

causes of change by using statistics whereas qualitative researchers are concerned with understanding the social situation or event from the participant's perspective (McMillan & Schumacher, 1993).

The study employed qualitative research which uses multiple realities that are socially constructed through collective and individual definitions of the situations. I chose qualitative study because I wanted to find out how I transformed my content knowledge in order to teach gold mining and how my understanding of relevant content changes as I teach. The answers to these research questions depend on the social interaction I have with my learners and the collaboration team. I wanted to research my own teaching practice therefore I chose self study as the methodology. According to Schumacher and McMillan (2006), a research methodology is used to obtain evidence to answer research questions and this provides methods for conducting the study. Samaras and Freese (2006) describe self study of teaching as

> "…. a research done by teachers to systematically and critically examine their actions and their context as a path to develop consciously driven mode of professional activity" (p.12)

Self study is the study of one's self, where one must make one's personal feelings and fears known to the bigger community. This is done to allow other people such as teacher educators, other teachers and curriculum developers learn from the study. There are two types of self study – formal and informal. In informal self study the researcher will not make his/her research public. In formal self study researcher publicises the research. Thus according to Samaras and Freese (2006) this self study is a formal self study as it is towards a degree qualification. According to Samaras and Freese (2006), teachers doing formal self study need to write a research report. I did this study especially to inform other teachers out there that it is normal to fear teaching new content.

The self is central in the self study. It is initiated by a teacher who wants to improve his/her practice (Samaras & Freese, 2006). Even if the aim of the study is to grow professionally, self study does not start with the teaching practice. Firstly it looks at ones personal history, beliefs and thinking. Secondly, it deals with the interactions one has with the collaboration team and

learners. Lastly, it deals with seeing one's growth personally and professionally. Self study has a number of features that one has to collect and analyse verbally. That is what makes it qualitative research.

3.3 Participants

The choice of participants in a qualitative study is the crucial part of the study. People who are participants must be the ones that assist the researcher to get a better or bigger picture of the process studied by answering questions or doing certain things. According to McMillan and Schumacher (2010), choosing knowledgeable participants about the study helps the researcher to increase the utility of information. Since this study is a self study, I am the main focus of the study. My three grade 11 physical science learners and collaboration team assist in informing me on how my learning and teaching practice change as I teach the new topic in the new curriculum. I chose these learners because they were doing grade 11 the same year when the new curriculum was implemented in grade 11 (as mentioned in Chapter 1) and they were my learners who knew my old way of teaching.

3.4 Data Collection Methods

Data were collected in the form of a reflective journal, video recorded lessons, group interviews and collaboration team. However, it is worth acknowledging that since this study is a self study there was no piloting of methods. Below is the explanation on why each method was used.

3.4.1 Reflective Journal

A reflective journal is a diary where the researcher/teacher writes about her personal feelings, fears, challenges and successes that occur before, during and after the study. Ideally, it should be written daily so that the researcher does not lose any important data. According to Altrichter, Posch and Somekh (1993), the ethics of a daily journal are that it should be kept confidential. No one should read it except the researcher and the collaboration team. Curriculum change affects teacher's attitudes, beliefs and values (Elliot, 1991). This study was done to find out how I reacted to the curriculum change.

A reflective journal is done by the researcher to write about self, contributions from the collaboration team, colleagues and learning and behaviour of learners. The researcher/teacher needs to be honest to him/herself when writing the daily journal (Samaras & Freese, 2006). She should write in detail about what is going in her mind, around her and what she learns from the experience. Withholding data results in poorer findings which may be mere generalities. According to Samaras and Freese (2006), a self study is about who the teacher is, and from the journal one can understand who the teacher is by the way it is written and its content. The data in the journal comes from me. This is a disadvantage of a journal in that it is subjective. According to Opie (2004) subjective knowledge belongs to the individual as a result of her own thoughts and consciousness. I counteracted subjectivity by triangulation, linking my journal's content with what I got from the other research methods like group interviews, video recorded lessons and learners' feedback.

3.4.2 Classroom Observations using Video Recording

Video recording helped to answer the question on how do I transform knowledge for teaching the content. Hitchcock and Hughes (1989) claim that a classroom is a very complex social situation. There are many things that happen in a classroom during the lesson and many factors can be learned from that situation. Video recordings record both verbal and non-verbal human behaviour on the physical environment (Opie, 2004). I needed to see movements, facial expression, gestures etc. Altricher, Posch and Somekh (1993) said that this would assist in detecting confusion or whether learners understood the work.

Video recording of a lesson is not the only way of doing classroom observation. An observer can come and watch the lesson and record whatever it is that interests him/her. The number of observers can be increased so that different things can be noted. I used a video recorder because I wanted to observe myself and also to allow my collaboration team to watch and comment on what occurred in class. Another way of doing classroom observation is to use an audiotape, which is used to record the voices. I did not use an observer or audiotape because I wanted to see how I taught and reflect on it before discussing any changes with the collaboration team. Observation is not objective. It depends on who was video recording and how the videotape was made. It can be very difficult to analyze especially if the person that is recording is not a teacher and there was no briefing before the lesson. It is good to use a video tape to record classroom

observations because they record certain things that I as a teacher did not see in class while I was teaching and I had to analyse or interpret them.

Other problems a researcher can face when using classroom observation are:
Learners can act in a different way due to the presence of a camera (Opie, 2004), observation tends to be acted upon (Altricher, Posch & Somekh, 1993) to please the researcher. This makes the whole observation biased and the role of power relation comes into place. It can also be time consuming (Opie, 2004). It can be diffuse, and details get lost because the scope is too wide (Altricher, Posch & Somekh, 1993).

To these counter limitations of the self study I asked a colleague and my principal to videotape my lessons. I asked them because I hoped learners would react less with familiar people in the classroom. I explained to the learners beforehand what the study was about and what I was going to use to record the lessons. The classroom recordings were not time consuming because I used normal school periods. The periods were 45 minutes long. The information from the video did not diffuse because the collaboration team made sure that I focused only on answering the research questions as we watched the videos.

3.4.3 Group Interviews

This study uses qualitative research where the answers to the research questions depend on how I interacted with learners and myself. An interview is an essential part of most types of social research Breakwell (1995). This means that the researcher must have a systematic way of collecting data using interviews. The interviewees should not feel uneasy or scared to answer questions due to the body language, environment or interviewer's language. Interviews should allow the respondents to say what they think using their own ideas, feelings, expectations and insights (Opie, 2004). It is not advisable to interview a subject who is too familiar with the interviewer as the subject may try to please the interviewer by providing answers that please him/her. Griffiths (1998) says that when the researcher is open about the aims of the research, more valid data is collected. It is the duty of an interviewer to make sure that an interviewee is comfortable and also feel that what he/she is saying is important. The interpersonal skill that I regarded as most important is the willingness to listen (Opie, 2004). Listening is a skill which interviewers must have and also should pay attention to tone of voice and to be non judgmental

(Opie, 2004). The outcomes of self study research rely on the quality of information that was gathered during data collection. The more information that is collected, the more learning there is about oneself.

I used semi-structured interviews. A semi-structured interview is an interview which is more flexible than a structured one. It has pre- determined questions but probing can take place in between the questions (Opie, 2004). The main aim of an interview is to encourage respondents to develop their own ideas (Opie, 2004). When interviewees are being probed, they use their own words to explain their ideas and to explain the depth of those ideas. They use language that is comfortable for them. Sometimes language can hinder communication due to lack of vocabulary. Breakwell (1995) regards children as difficult people to interview and they may say they do not know which could mean a number of things. I interviewed teenagers aged between fifteen and sixteen, whom I regard as people who know right from wrong and they already have goals for the future. I structured the interview questions in a way that encouraged them to disclose their own opinions. Learners were interviewed after lessons. The interviews were not long because I did not want learners to get bored. I audio taped the interviews but learners were consulted about the audiotape because others might not feel comfortable when it is used (Opie, 2004). Making the transcripts from the audiotape is time consuming but it is better than taking notes while doing an interview (Breakwell, 1995). Learners can be irritated during note taking and find the whole interview boring and time consuming.

I decided to use group interviews. The good thing about a group interview is that it helps finding out what people are comfortable to discuss. It is all about social interaction where respondents can talk about things that are not personal to them and they are free to discuss them in front of others. They also share ideas with each other, yielding richer data. It takes less time compared to an individual interview and a number of ideas can be discussed during that period. The researcher can avoid a situation where one person dominates the interview by trying to make other respondents contribute (Opie, 2004). It is possible that not all learners will talk during this interview but as other raise their views, some learners may think about it and that idea may be explored further.

3.4.4 Collaboration Team

A collaboration team is a group of people who assist the self study researcher move beyond his/her own personal views by hearing other perspectives (Samaras & Freese, 2006). These people give support, new ideas into the study and deals with different perspectives. According to McMillan and Schumacher (2010), a collaboration team is one of the strategies of enhancing reflexivity and they refer to a collaboration team as peer debriefers, which hold discussions that make explicit the tacit knowledge that the researcher has acquired. During the collaboration team meetings, these people pose questions that force the researcher to understand his/her own posture and its role in the study. This collaborative reflection provides opportunities for clarifications, probing questions and alternative explanations because when an individual is reflecting on his/her own, the ideas are limited. The collaboration team functions well if there is openness on the side of the researcher and trust amongst each other (Samaras & Freese, 2006). When there is trust, the task of collaborators which requires them to be open minded to new ideas will flow easily.

The collaboration team met for the first term to inform me and my fellow colleague to read and understand the topic of gold and coal mining. As we were learning the content, we had to decide on the Big Ideas in preparation of the CoRe (as discussed in Chapter 2 and 4). This group gave me lot of support before, during and after data collection. These are social interactions, where these people were advising me on my development, the things I needed to change and those that I did not need to change. They made us (me and my colleague) develop lessons for our studies which were later given to the Education Department. These were some of the new insights that came up during our discussions. They helped us with even technicalities of the research like which cameras were best to video record and devices for audiotapes. We discussed everything from understanding the content knowledge at the beginning to how to analyse data. The collaboration reflections were also written in my reflective journal (see Appendix C) since Samaras and Freese (2006) said that collaboration reflection is essential to the self study.

3.5 Data Collection

Data were collected in 2007. Since this study is a self study we started a collaboration team in 2007, which consisted of my supervisor an expert in chemistry, a Phd student acting as an

assistant supervisor, a fellow master's student (Miss Fuze) and me. Miss Fuze was also doing a self study on teaching coal mining, another new topic in chemical systems in grade 11. I started keeping my reflective journal before beginning to read the gold mining content. I wrote about the fears I had before. The collaboration team was formed long before I started to teach gold mining. This was to give me and Miss Fuze time to learn the content. Both of us met to make the first draft of the CoRe (as explained in Chapter 2, CoRes and Pa-PeRs). Later the collaboration team met to improve the first draft of the CoRe (see Table 4.1 in Chapter 4). The collaboration team met on a regular basis to discuss the problems me and Miss Fuze had concerning the understanding of content knowledge and challenges we faced when developing the lesson plans. We also met during teaching to monitor its progress.

Gold and coal mining lessons were developed by my colleague (Miss Fuze) and me. These lessons were used for data collection and they were further developed after the study to be used by the Department of Education. The idea of lesson development started in one of our collaboration meetings. Initially these lessons were for our self study, but as time went by another idea came of giving them to the Education Department. As I have mentioned above that the collaboration team helped with lesson development, clarifications of concepts that were necessary for this study was also done by the collaboration team.

I taught the four lessons in each of the three grade 11 classes at my school. The lessons were delivered slightly differently depending on the learners' voices from previous classes (see Appendix D). After each lesson, I interviewed learners on how the lessons were. I had planned to use double periods for the first lesson but learners from the first class took long to finish the practical work and also cleanup. Learners had activities done during the lessons and homework. These activities were used to assess learners' understanding. I was unable to video record all lessons because the recording depended on the availability of the video recorders.

3.6 Rigour

A research project is undertaken to get better knowledge as Griffiths (1998) stated. But the readers have to believe and trust the way that knowledge is acquired. The researchers must

ensure that they account for validity and trustworthiness. As Scaife (2004) said that the researcher writers must gain trust and confidence of the readers.

3.6.1 Validity

Validity is about the research tool actually measures what it is supposed to measure (Scaife, 2004). It shows the link between result explanations and what really happened in the study. According to Schumacher and McMillan (2006), validity of qualitative research measures the extent at which the researcher's interpretations have a mutual meaning as those of the participants. Since qualitative research relies on interpretations and using multimethods to assist with the triangulation. In this study I used a reflective journal, video recordings from classroom observations, collaboration team and verbatim accounts from learners' interviews for triangulation to ensure credibility. In a self study, according to Bell (1999), validation should be an ongoing process.

3.6.2 Trustworthiness

Trustworthiness in self study research had led to other researchers not taking self study as a genuine research. Bell (1999) argued that if self study researchers can be more explicit by naming of all knowledge contributions that has a major role of increasing trustworthiness in a self study research. The trustworthiness of this study came from connections of knowledge from the study with that of educational policy and the theories from the literature review in Chapter 2.

3.7 Data Analysis

Data was analysed using CoRes and PaP-eRs to portray the developing of my PCK and Iused Rollnick et al.'s (2008) tailored model of PCK to analyse the manifestations that occurred throughout this study. These are discussed in more detail in Chapters 4 and 5.

3.8 Ethics

Ethical concerns are about the rights of the subjects and the researcher getting the truth. The researcher must not violate the participant's right in order to get the truth. The Consent letters must be given to relevant people or organisation to get their permission(s) and must be signed by the participants (McMillan & Schumacher, 1993).

A submission was made to the Ethics Committee of the University of Witwatersrand for permission to do the study and the protocol number was granted. The Gauteng Department of Education also received my request to use learners at their school.

The participants in this study were learners, and under age to sign forms without their parents' consent. Thus the consent forms were signed by both parents and learners (see Appendix A_{2-3}). In the consent forms it was clearly stated that the study is about me looking at how I teach the new topic in the new curriculum and lessons had to be video recorded.

I made it clear to learners that their anonymity was guaranteed. Learners who did not sign the consent forms or did not want to be video recorded were seated on one half of the class. Because learners had to submit two forms, only those that had two forms were video recorded. I used pseudonyms in the transcripts to identify them. I also mentioned that the information collected would be used purely for study purposes. However, some clips of video may be shared with fellow researchers at seminars and conferences. The information will be kept in safe and secure place for up to the period of 5 years before it is destroyed.

3.9 Conclusion

This chapter dealt with the research design, methodology and methods used to collect data in this study. The next chapter will discuss the analysis of data collected from the research methods discussed above and results obtained.

Chapter 4: CoRes and PaP-eRs

4.1 Introduction

This chapter presents a portrayal of my PCK for teaching gold mining. Loughran et al. (2004) produced two methods of portraying PCK known as CoRe and PaP-eR as discussed in Chapter 2. The CoRe illuminates the teacher's content knowledge for teaching a specific topic. The CoRe shows the teacher's deeper understanding of the topic, concepts that will confuse learners and the teaching strategies. According to Loughran, Berry and Mulhall (2006), the PaP-eR allows the reader to examine the teaching and learning situation in which the content shapes pedagogy. The PaP-eR makes the teacher's tacit knowledge more explicit by giving the reader a sense of the actual teaching that occurred in class.

4.2 Construction of CoRes

In the study done by Loughran et al. (2004), a CoRe was used to provide an overview of how a group of teachers worked to understand the teaching of the subject matter knowledge of a specific topic. This shows the importance of teachers learning the content first before developing a CoRe. The content is represented in the way that teacher's understanding of certain aspects within the topic, learners' prior knowledge and teaching strategies are addressed.

A CoRe is made up from Big Ideas and Prompts placed in a grid (See Table 4.1). Mulhall, Berry and Loughran (2003) describe a Big Idea as an idea that has an impact on scientists'

understanding of the world and how teachers use it as the key to understanding of the topic for a particular topic. The Big Ideas are written on the top row of the CoRe and the prompts are placed in the first column. Each Big Idea has eight prompts that need to be answered to get a teacher's clear content representation of a particular topic. In this study, the CoRes were used differently to Loughran et al. (2004) in that the Big Ideas were determined by myself and the collaboration team and the prompts were answered to describe my teaching of gold mining and my fellow master's student's idea of coal mining as the teaching was planned and executed.

In the early parts of the study such as lesson development, it was not possible to respond to all of the prompts because a teacher does not know what will happen in class when teaching that topic (Loughran et al., 2004), especially with regard to learners' difficulties. As the teacher's experience increases then those prompts are gradually filled in. Thus the CoRe becomes a dynamic document, changing through the study.

At the end of teaching gold mining I had developed a final CoRe which is made of my earliest CoRe and the final one, combined in Table 4.1. They are not the same, because I added the information when there was need to do so. Below I discuss how each CoRe was developed. The italicised print shows the sections that were added to the initial one.

The Big Ideas that were brainstormed in the reference group were

- Significance of the earth's crust
- Beneficiation
- Environmental and social impact.

The prompts used to explore these Big Ideas were

1. What do you intend students to learn about this idea?
2. Why is it important for students to know this?
3. What else you might know about this idea (that you do not intend students to know yet)?
4. Difficulties/limitations connected with teaching this idea.
5. Knowledge about students thinking that might influence teaching this idea.
6. Specific ways that influence your teaching of this idea.

7. Teaching procedures
8. Specific ways to ascertain the students understanding of this idea.

	Significance of Earth Crust	**Beneficiation (Extraction & Process)**	**Environmental & social Impact**
1. What do you intend students to learn about this idea?	The lithosphere has different rocks with different chemical composition; The location of specific minerals determined by settlement patterns How different minerals & elements can be found	Knowledge of chemical properties of raw materials whether (elemental or combined form) How it is mined Extraction of gold from the ore Gold is a valuable, precious enduring metal, good conductor, non tarnishing nature, density;	Scientific decisions can affect how people live.
2. Why is it important for students to know this?	Some materials are found as elements mixed in rock and others are in compound form.	In an ore gold is found as a compound and that is why extraction is done and how.	Decisions taken by people now can affect the future generations There are

	Significance of Earth Crust	**Beneficiation (Extraction & Process)**	**Environmental & social Impact**
	This will help in understanding the different types of mining. To know what people did before mining from stone age to iron age – development of technology.		advantages and disadvantages of mining.
3. What else you might know about this idea (that you don't intend students to know yet)	Earthquakes, plate tectonics *Types of rocks, volcanoes, core of the earth and magma*	Exact size of the shaft especially its breadth *Electroplating and fake metals*.	
4. Difficulties/limitations connected with teaching this idea	Not to lose track when dealing with this section and end up explaining origin of types of rocks. *Controlling learners' mind to*	*Processing, complex compound ions*	Learners may find it difficult to control their emotions during the role-play and may continue arguing after class time.

	Significance of Earth Crust	**Beneficiation (Extraction & Process)**	**Environmental & social Impact**
	focus only on the topic at hand not to lose direction since they already know something about this topic from geography		
5. Knowledge about students thinking that influences your teaching of this idea	The lithosphere is done in grade 10 geography.	Knowledge of oxidation and reduction (oxidation numbers)	Use the JHB context of the mine dumps. Safety of the miners in the mines. Mining is a business, where poor people get jobs and mine owners become rich. *Miners leaving their families and spreading of HIV/AIDS*
6. Specific ways that influence your teaching of this idea	Use a scientific approach so that they will be able to distinguish between science and geography.	Importance of gold and why is it only 98-99% not 100%. This may mean that it is not pure gold that we are	Use the knowledge of what is happening around them, newspaper articles. There are meetings going

	Significance of Earth Crust	**Beneficiation (Extraction & Process)**	**Environmental & social Impact**
	Use a scientific approach so that they will be able to integrate science and geography.	discussing.	behind closed doors before a mine opens or is constructed (stakeholders).
7. Teaching procedures	Start with the practical work to show the difference between science and geography. *Activity: Read materials on ancient mining and answer questions*	Activity tracing the whole extraction of gold (group work) or teacher teaching the class *Practical work on extraction of copper*	Group discussion and role-play. Report back on the conclusions and it must be clear to them that there is no single answer but at the end of the day decisions have to be made.
8. Specific ways to ascertain students' understanding of the idea	Use learners' worksheets.	Use learners' worksheets.	Ask learners' questions at the end of the lesson.

Table 4.1 Combined CoRe (1 and 2)

4.2.1 Discussion on CoRes

Developing the initial CoRe was a challenge for me because I had not taught this topic before. When dealing with this topic I felt like a novice teacher even though at the time I had 10 years experience in teaching science. As Loughran et al. (2006) explained a CoRe produced by experienced teachers contained more information than one produced by a novice. After reading gold mining materials, I attempted to think of Big Ideas, but it was not easy. I waited for our next scheduled collaboration meeting where I got help with the Big Ideas from the collaboration team. In that meeting, we discussed all the prompts for each Big Idea. Some of the prompts were not filled in since I had no experience in teaching this topic. Loughran et al. (2004) said that a CoRe can be filled in different ways. Some people fill it across using one prompt and others deal with one Big Idea and fill in all the prompts.

The second CoRe has the same initial elements as the first one, but I added new insights that emerged as I taught the topic. Below I discuss how the Big Ideas were constructed and how the prompts were filled in for both CoRes.

Construction of the Big Idea 1

The topic of gold mining is a topic within chemical systems in grade 11. Big Idea 1 is about exploiting the lithosphere which is the topic from the NCS. Learners are introduced into mining by first understanding what is in the earth's crust. Although my topic was gold mining, we agreed as a collaboration team that this was a good introduction for learners rather than starting with gold mining. Learners should have done this in the grade 10 geography class. I was aware that my learners did this work in the previous year, but it was not in the context of science.

(I reflected – I battled to understand this topic because I did not do geography at school. My learners knew this topic better than me. Must I teach it? What if they take over the lesson? What will they get out of the whole thing? But at the same time if I run away from this topic what will I do when I have a science class that does not do geography?).

This is what pushed me to start teaching the lithosphere in a scientific way. The scientific way came when I tried to answer prompt 7 above about the teaching strategy to be used in the lesson. I wanted learners to understand there is science of rocks and minerals. Whilst they knew about describing rocks from geography they should also understand the work of mining chemical engineers in the mine. My teaching strategy was to use practical work for learners to discuss the solubility of substances. Within the same lesson I wanted them to read passages about old methods of mining. This was to give them the knowledge about history of mining and to let them read about science. Our new curriculum requires learners to read a lot especially contextualised stories. In my teacher centred way of teaching I had never gave them stories to read. I wanted them to be aware that even in science there are stories to be read.

Construction of the Big Idea 2

The second Big Idea is about extraction and processing of gold. This is a topic from the NCS. This is one Big Idea where we filled in the prompts from top to bottom, because we were experienced in terms of the science. Prompt 5 is about learners' prior knowledge and this is one of the key things that shapes the lesson according to Loughran et al. (2004). Learners' prior knowledge leads a teacher to use proper teaching strategies to treat misconceptions as well as to learn the new work. For extraction of gold, learners should know reduction, oxidation and oxidation numbers. These concepts were taught earlier in the year.

(I reflected – I remember when I was teaching redox reactions I used a demonstration. I put a magnesium strip in a copper sulphate solution. If I can give them a chance to do on their own that will be a cherry on top, because they'll be able to see for themselves that there are redox reactions and they are used in the extraction of minerals).

This knowledge drove me to use practical work on extraction of copper, for which the equation is less complex compared to the gold one (see Appendix D on lesson 2). Furthermore, there is an obvious cost implication to using gold in the laboratory.

Construction of the Big Idea 3

Big Idea 3 is about the social impact of science and the environment. This is a new learning outcome in science in the new curriculum, where learners should answer contextualised questions. This learning outcome allows learners to use their general knowledge and the information they get from the media. It makes them aware of their environment and how other people's decisions affect them. This outcome intends to promote South African citizens that can make informed decisions (DoE, 2006).

For this Big Idea, the collaboration team agreed on using role play as a teaching procedure (prompt 7). It was chosen because it allowed learners to use their general knowledge as well as contextual understanding of their environment (prompt 5, learners' prior knowledge). My learners were all staying in Johannesburg and so they had seen mine dumps before. According to Loughran et al. (2004), successful teachers plan their teaching around learners' common held ideas about the topic. They further argued that this increases the learners' level of interest about the topic. The second CoRe has miners leaving their families and the spreading of HIV/AIDS in the mine as well as within their families. This was said by learners due to their level of interest in the topic.

The collaboration team could not fill in prompt 3 (what you do not intend learners to know yet) because the role play allowed learners to be the stakeholders of that particular issue. Learners were using their own relevant knowledge. Even after teaching this topic of gold mining, we could not limit their knowledge.

4.2.2 Conclusion on CoRes

The CoRe is one method of capturing and portraying PCK. It is where the teacher's CK is combined with the learners' prior knowledge, teaching procedures and the curriculum knowledge. A CoRe is a solid base of teacher's PCK because it provides insights into the decisions teachers make when teaching a particular topic (Loughran et al., 2004). From the combined CoRe I can see the growth of my PCK which came from learning the content, debates held during collaboration meetings and teaching the topic. According to Shulman (1986), PCK is more than the teacher using CK only but also a combination of knowledge that guarantees teaching and learning.

4.3 Construction of PaP-eRs

The PaP-eRs could be in the form of a narrative or stories. They are about teaching the content in a particular context and help illustrate aspects of PCK. The PaP-eR thus illuminates the CoRe (Loughran et al., 2004). PaP-eRs have different formats and the data were collected by means of a video recorder. In my study, the comments also emerged from my journal entries. These comments were used to document my approaches and ideas in order to review my own learning as well as analysis of learners' work (Loughran et al., 2006).

The PaP-eRs illustrated in the paragraphs below were linked to the lessons I had developed (see Appendix D). Only the first and fourth lessons are discussed. These PaP-eRs use teaching journal entries to illustrate how the lessons were taught. This is to give insight on how learners contributed in the lessons as well as my reflection on the way I was teaching.

4.3.1 PaP-eR 1: Does a stone dissolve?

Exploiting the Lithosphere

In the lesson, learners had to do practical work and read extracts from different books to fill in the worksheet. I wanted them to do practical work about solubility of substances and read about where these came from.

Learners went to their places prepared to do the practical. I handed out the worksheets. They read for about a minute or two and started to do the practical. In this practical they were trying to see the effect of two mystery solvents, X and Y on rocks and salt crystals. I used water for X and paraffin for Y. My intention was to make learners find out which sample dissolved and give a reason using the intermolecular forces they learnt in the previous lessons.

Firstly, they were expected to scratch the samples with a sharp object to see if scratch marks are visible and write down the reasons for the results. Secondly, they had to see if these samples dissolve in X or Y and they had to write down their reasons. The students got the impression that they needed to scratch the samples in order to make a powder which they would then test with the solvent. That took a lot of time.

(I reflected – why are they doing this? Were the instructions not clear enough? I had to do something).

I went to the front of the class to tell them that they were wasting time by scratching the solids and that they should just put one or two pieces of each sample in a beaker and add X or Y. They then continued without any hiccups and finished off the practical activity. But they still battled with the reasons for what they were doing.

(I reflected – I had to help them now since there is no way forward. But this time I will not guide them from the front. I will use their groups' understanding of dissolving).

I moved around asking them what do they understand about dissolving and what make substances to dissolve in other. They started coming up with intermolecular forces. So they went back to the first part where they had to scratch and started filling their answers using the intermolecular forces.

(I reflected – finally they understood what they were doing and saw that they have to use their chemistry knowledge to answer the question about the reasons! Why do learners always separate things that they are doing. Since chemical systems is part of chemistry and is the last chapter therefore it means that we need all the knowledge we learnt before. I felt like saying it to them but I thought probably by now they are aware of it, I'll say later. I am not too happy about the time they took to do the practical and seemed confused. Why did they take so long? Was my practical difficult or maybe the purpose is being hidden by extraneous detail? How will I find out what really happened?).

4.3.2 PaP-eR 2: Learners' Voices

Immediately after the class I invited learners to give me feedback on a focus group interview. Initially learners did not want to open up. My first question was " how did you find the lesson?" There was no answer. The second question was " what did you learn?", still no answer. I said "come on guys please help me, this is for my study and for me to learn from it!" I added that if I

was an author of science books, is what I used correct or wrong from their point of view. From then all the classes started to say something.

Learners: Ma'am the practical was boring.

Teacher: Why do you say it was boring?

Learners: It is because you gave us too many stones and only one sample of a salt crystal.

Teacher: So what is boring in that?

Learners: It is because the answers or results are obvious stone will never dissolve in water only salt will.

Teacher: How do you know that one of the solvents was water and that the crystal was salt?

Learners: Salt dissolves in water and stones do not.

Teacher: Then why does salt dissolve in water not stones?

Learners: Ma'am salt is polar and water is polar. Like dissolves in like. Stones did not dissolve because they have stronger intermolecular forces.

Teacher: If you say one of the solvents is water which one was it? Is it X or Y?

Learners: It was X because salt dissolved in X.

Teacher: What is the name of Y?

Learners: Y is paraffin?

Teacher: How did you know that Y is paraffin?

(The discussions went on about polar and non polar substances)

Later ....Learner: Ma'am today's topic is about exploiting the lithosphere why then did you use stones only not soil?

Teacher: Yes, I did think about using soil but the problem with soil was that it contains certain substances that will dissolve in water. This will have caused some confusion because I wanted you to see things that can dissolve and things that cannot.

(I reflected – to be honest with myself I never thought of using soil when I designed this experiment. This question caught me off guard but I had to come up with an answer immediately. Fortunately the idea of how murky solution of soil confuses people came to mind. I thanked God for that).

Teacher: what do you know about the lithosphere?

Learners: Our geography teacher taught us in grade 10 about the lithosphere. We know that it has to do with things in the ground and how soil is formed.

(I reflected – it would have been a good idea to talk to the grade 10 geography teacher and get a book when I was designing these lessons. At least I know that they have done lithosphere in grade 10. But still I have to very careful maybe there are certain things they may ask that I do not know).

Teacher: Then, what is the aim of this practical or have you learnt anything from it?

Learner: To me this was just a waste of time because I do not see myself working with stones in future?

Teacher: Ok, it is fine that is you own view. Somebody else?

(I reflected – I had to be calm so that others can feel free to comment, but deep down I felt torn apart that this was a total waste of time. These learners did not learn anything except the aspect of polarity)

Learner: I for the first time seen for myself that polar dissolves in polar and non polar will not dissolve.

(I reflected –this one is trying to say something nice so that I do not feel offended after what the other learner has said about the stones and the future. But any way it is not his fault. To be honest he knows or has seen salt dissolving in water and that things like paraffin or oil do not dissolve in water)

Teacher: Ok, somebody else.

Learner: What I have learnt is that scientists do work with stones and test for something. Whatever results they find they use them to find more minerals that are in the lithosphere. So guys let us wait and see this is just an introduction more is about to come.

(I reflected – this is what I was hoping for. At least one of them understood where I was going. I felt very proud that even those that were saying this was a waste of time learned something from their classmate).

4.3.3 PaP-eR 3: From Stone Age to Copper Age

This part of the lesson took place the next day since they took long to finish the practical work. Learners were reading photocopied notes and grade 11 textbooks from Stone Age to Plastic Age. They read these articles for three periods and on the fourth day there was a report back on what they had learnt. I only made one set of photocopied notes (enough for one class) to read from. They were not able to take the notes home with them.

(I reflected - I did feel bad about my decision but at the same time I wanted to see how fast they could read at the given time especially for exam purposes. I wanted to rush them but at the same time they have to learn. They were learning at their own pace).

On these days I was moving around listening to their discussions about the readings. I answered the questions they asked. Below is an example of some of the questions that learners asked.

Irvin: Why should we know about what people in the olden days were using?
Teacher: Do not worry you will know at the end of this activity.

(I reflected – Many learners do not like doing things which are not relevant to them. They always want to do things that are of interest to them as if education is there to entertain them. Some learners kept quiet and continued reading showing interest).

Thandiwe: Where did the people in those days make their ovens to melt the iron?
Teacher: They use to dig holes in the ground and make fire in them.

(I reflected - she is asking something that is not in the notes or books this means that she has a little bit of knowledge about mining. Days later - I should have asked where she got that information or what else she knew about melting of metals).

Rapelang: How did they know where to dig to find the iron ore?
Teacher: It was sometimes by coincidence to find the correct land but they should have way that I do not know. Because it was not easy to find the metal ores that is how science and geology is helping us to find these minerals easier.

(I reflected – I have to find out about this. I never did and it is bad that Thapelo never came to me to find out about the olden days of mining. (This is a bad way of teaching). It might happen that he never came back to me because he lost his trust in me. But I got carried away with the study and I forgot).

There were comments from some groups about how they enjoy finding out new information on their own. Although others were taking a long time to read but they did contribute when the groups were discussing their answers from the worksheet.

(I reflected – is my old way teaching hindering my learners' opportunities of discovering the knowledge on their own. Am I really spoon feeding them? Is it that bad? But maybe it this works because it is the knowledge that makes sense to them, it is history and even a primary school learner can read and understand this. There are certain concepts of science that I have to explain. Yes not all of them. This tells me that I should try and be very selective when teaching to try not to teach everything and let learners fend for themselves. This feels like I am undermining their intelligence).

Report back from group work

Learners showed interest in what they were doing by they way they were reporting back. They mentioned their answers for different questions but they were keen to say what they learnt.

First group

Xolile: At first I and my group members thought this was a waste of time. But as we went on with the activity we realized that knowing what the olden people were doing up until now shows us the growth in technology.

Teacher: What is that growth you are talking about?

Xolile: Ma'am you see this activity made us see how lucky we are living in this era. There are lots of things like metals that have been discovered and we are using them. We should be very proud of this new technology.

Teacher: What is technology?

Jeffrey: Technology is what people make for a better living, like telephones for people to communicate and those phones have changed to cell phones for to communicate at all times.

(I reflected – this shows that they understood the readings if they are able to summarise the readings like this).

Second group

Vesego: We did not know that there are different types of mining. Now we know that there is open cast mining and underground mining. This is because of where the minerals are found. What makes it more interesting is that we found out on our own you did not tell us.

Teacher: This means that you do not need me from now onwards

Class: No ma'am.

Teacher: What does that mean?

Morgan: You see ma'am there are things where we need you and sometimes we can do it on our own.

(I reflected – this comes up again. But this time he is saying what I had already said. Teach different topics differently).

4.3 Conclusion on PaP-eRs

PaP-eRs are the real encounter that occurred in the classroom. They complement CoRes. PaP-eRs provide evidence that what CoRes were saying really led to learners learning. They also provide information on how the lesson was delivered and the teacher can tell of any changes that occurred during the lesson and why. Teacher's PCK can also be evident when s/he answers learners' questions. Learners can sometimes put teachers at the tight corners especially if their CK is well developed. Learners' questions may lead teachers to mention concepts that will confuse them. Although learners asked questions that were not expected especially that one about the soil, I had to use my science teaching experience and at the same time wear my teacher cap. This was another way where my PCK was growing. I knew what the curriculum wants me to do and how I planned my lesson, even if they were bored I had to stick to sequence of the

lessons. According to Loughran et al. (2004) successful science teachers do not over simplify concepts in a way that can mislead learners.

4.4 Conclusion

This chapter dealt with the ways in which I captured and portrayed my PCK in and out of the classroom. CoRes showed how my content was represented before and after I taught. The prompts in the CoRe serve as guidance on how to go about making it. The Big Ideas were a bit challenging at first but they got clearer as time went by. CoRe forces one to think about what is it that you want learners to learn and plan on how to deliver that. The usage of the Big Ideas assisted me on sequencing my lessons as well to find the appropriate practical work for learners. PaP-eRs were used to give evidence of what really happened in the classroom. They also allow the teacher to explain how did the lesson go and why. The teacher's PCK allows the teacher to be flexible in class and address challenges that might come up during lessons. In the next chapter I focus on other aspects of PCK.

Chapter 5: Development of my Pedagogical Content Knowledge

5.1 Introduction

In this chapter I discuss how my PCK was developed from my knowledge domains. As a teacher, I possess knowledge of the content, curriculum, learners and context. This outlines how my PCK developed from these knowledge domains.

5.2 Data Analysis

Data analysed in this chapter was sourced from lesson observations, reflective journal, interviews and learners' worksheets. This data was analysed typologically using themes which involve analyzing data using predetermined categories (Hatch, 2002). The themes came from Rollnick et al.'s (2008) model of PCK. This model has main knowledge that informs the teacher's PCK, and this knowledge gives rise to the manifestations that occur in the classroom (Figure 5.1).

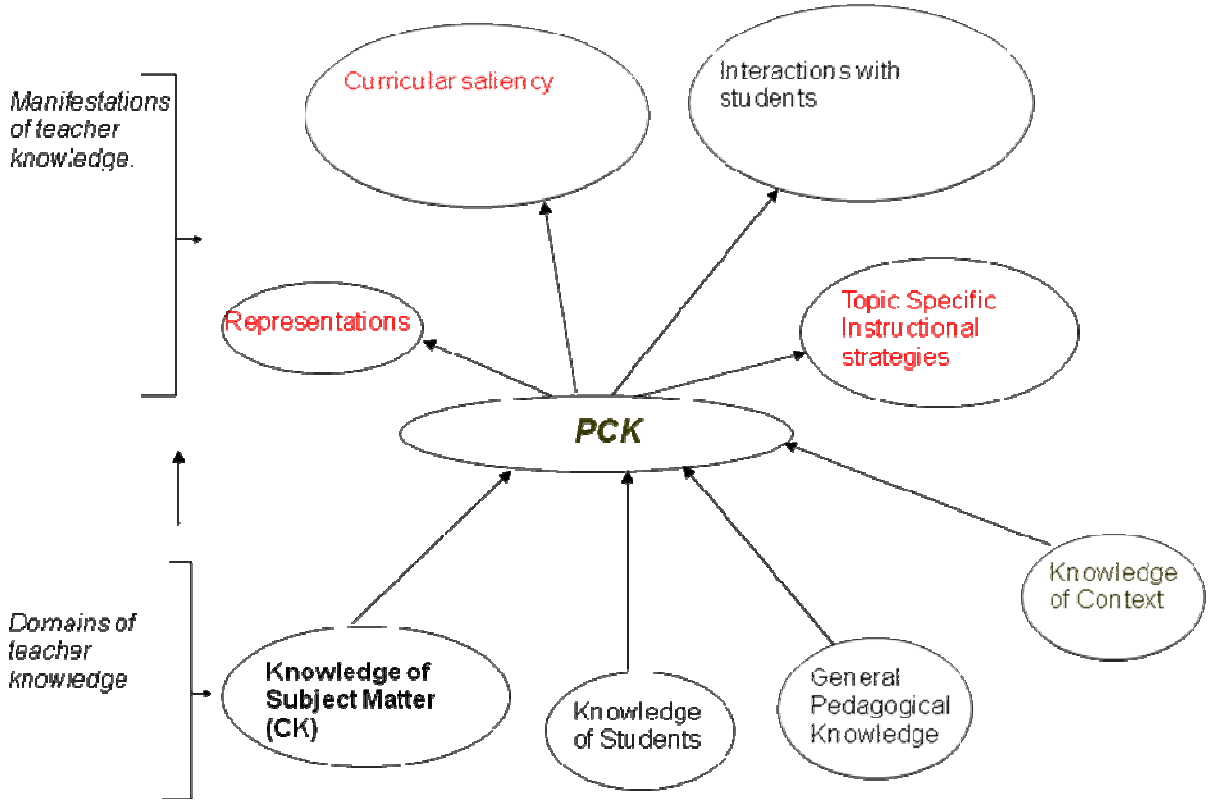


Figure 5.1 Rollnick et al.'s (2008) model of PCK

The diagram shows that PCK starts from the domains of teacher knowledge to the manifestations of teacher knowledge. What occurs in classroom was first designed by the teacher and planned very well on how it will move from one point to the other. Sometimes learners can change the pacing of the lesson or even the strategy depending on how they are learning. When the teacher changes something in the lesson that is part of the teacher's PCK. The teacher is aware that learning is not taking place according to what was planned and so for learning to occur, certain adjustment has to be made. The domains of the teacher knowledge also include teacher's background/history which can be his/ her qualifications and beliefs. I have always been teacher centred. Although I have used class discussions, I am always still in control. This study was self study to test my own beliefs that teacher centredness is not the only way learners can learn.

The teacher domains are explained in the table below (Table 5.1). These teacher knowledge domains combine to produce manifestations which are observable in the classroom situations (Rollnick et al., 2008).

Domain	Nature of knowledge
Knowledge of content	The teacher's raw untransformed content knowledge
General pedagogical knowledge	Understanding what counts as good teaching, the best teaching approaches in a given context, informed by knowledge of applicable learning theories.
Knowledge of learners	Appreciation of learners' prior knowledge, how they learn, their linguistic abilities, interest and aspirations.
Knowledge of context	All contextual variables influencing the teaching situation, e.g. class size, curriculum, classroom conditions, time available for teaching and learning and learners' socio-economic background.

Table 5.1 Teachers' knowledge domains

The manifestations that occurred during the lessons are discussed below linking them to relevant teacher knowledge domains, which are knowledge of content, curriculum, learners and context.

5.3 Manifestations of Teacher Knowledge

What happens in class is normally informed by the domains of teacher knowledge (Rollnick et al. 2008). Planning of lessons goes well because the teacher is all by him/herself and there are no external forces that can hinder it, as long comprehension has occurred. But when what was planned has to be put into action in the classroom, lessons can change depending on how learners are participating and understanding. The manifestations of teacher knowledge are when the domains of teacher knowledge are put to test (Bishop & Denley, 2007). According to Rollnick et al. (2008), there are four categories of these manifestations namely: topic specific instructional strategies, assessment, representations and curricular saliency. In this section I will show how these manifestations raised from the domains of teacher knowledge. Manifestations are shown in the top part of Figure 5.1 above, and how they were used to trace the development of my PCK especially in the classroom.

5.3.1 Topic Specific Instructional Strategies

According to Rollnick et al. (2008), topic specific instructional strategies are the teaching strategies which were outlined in the CoRe as explained in Chapter 4. Each Big Idea has its own teaching strategy. During this study I did not change the teaching strategies but I changed the time allocated for the first practical work. This was due to the fact that learners in the first class took longer to finish the work. One of my camera men was my school's principal. (From the video I was really frustrated on how slow the learners were when doing the practical. I kept on saying hurry up hurry up. Guys you are wasting time). He came to me after that lesson and said "I will suggest you tell learners the time they need to finish the practical so that they can time themselves"

Learners in the first class that I taught did not finish the practical on time because I lacked the skill of learners doing practical work. In my traditional way of teaching I demonstrated the practical work. During that period I kept on blaming myself for not giving learners enough written instructions. They looked confused. In the next two classes I changed the topic specific instructional strategy by informing learners at the beginning of the lesson in the second class and third class the time allocated for the practical work was fifteen minutes. (The lessons in the other two classes occurred on following day. I wanted to use double periods for lesson 1 because it was a bit longer. The other two classes' double periods were on the next day. I was calmer and relaxed during those lessons). These two classes did very well although they took extra five minutes to finish their work. From the video, these two classes discussed a lot about solubility. Below is an excerpt from the transcript.

Kabelo: Ma'am there must something about your solvent X and Y. It means that one of them is polar and the other is non-polar. That is why one substance dissolve and the other substance did not dissolve.

Teacher: What makes you say that?

Kabelo: Because when substances dissolve their polarity comes in.

Teacher: Is dissolving about polar nature of substances only?

Solo: Ma'am there are also intermolecular forces.

Teacher: Why are you talking about intermolecular forces?

Solo: Ma'am for substances to dissolve it means that the intermolecular forces of one must be weaker than the other one.

This is one class where most learners did not find practical work boring when interviewed, which came as a surprise to me. I expected the same response as the first class.

Nonhle: This work is an introduction to something we do not know. For the fact that it was done first then it means we'll need this knowledge along the way.

This class' interview went on to discussing who in the mining industries needed this type of knowledge about stones. They discussed about geologists and chemical engineers. I allowed them to discuss and learn from each other.

The topic specific instructional strategies were a manifestation of teacher knowledge which came from the knowledge of learners, which is part of domains of teacher knowledge. I knew what I have taught my learners and I wanted them to use that knowledge in order to understand the new topic.

5.3.2 Curricular Saliency

Geddis and Wood (1997) stated that curricular saliency is the knowledge of the teacher; that emerges from understanding the concepts or ideas that are before and after the relevant topic. The teacher does not say or do things that will lead to confusing learners. He/she knows what to say at the right time. Teachers try to eliminate noise during lessons which may lead to errors or misconceptions.

When I was learning the subject matter, I could recognize the topics of chemistry (grade 11), cyanidation and electrolysis. Both cyanidation and electrolysis requires the knowledge of oxidation numbers and electrochemistry. As I was learning the subject matter knowledge, I used the existing domains to understand the new knowledge. I learned using Hatano's (1996) way of acquiring knowledge, by restructuring. I wanted my learners to learn the same way. I had already taught them (learners) oxidation numbers and electrochemistry so they were able to cope with

this topic of gold mining. I did not use electrochemistry and cyanidation in the first two lessons. Even if I was aware of what they knew I did not want to create noise in their learning. The aim was to make them understand the lithosphere and the history of mining. The experienced teachers are able to do this with ease, because teachers can arrange their lessons well (Geddis & Wood, 1997). I took a decision to distance myself from them and their learning. At the back of my mind I knew that working in groups would help those who did not understand the work. Learners learn more in a social environment (Modau and Brodie, 2008)

This manifestation of teacher knowledge came from general pedagogical knowledge, knowledge of learners and CK. General pedagogical knowledge understands what counts as good teaching which does not lead to confusing learners. From CK I was able to see the topics I have taught before and which are required to enlighten this new topic.

5.3.3 Assessment

Assessment is used to ascertain learners' understanding of a particular topic (Rollnick et al., 2008). There are many ways teachers can use to find out if learners understood the scientific concepts or not. The lessons I used in this study had learners' worksheets. Most of the work done in class was groupwork and homework and this was individual work. I used groups in class so that they learn from each other. Homework was to reinforce what was done in class in a different form. In lesson three learners were doing practical work on extracting copper from its ore. They had to write down a scientific report on how they conducted a practical. The scientific report was written individually as it was the requirement of Department of Education for learners to have learning outcome 1 (LO1) which is knowledge of practical investigation.

The practical work was done in a 45 minute period and learners did not have enough time to do the scientific write up in class. I said that the report would be their homework in addition to that day's homework. For homework, learners had to draw concept map to give evidence on how they understood extraction of gold (see Appendix E). This activity was to articulate the extraction of copper to that of gold which they did not do in class. They had to learn about gold extraction not copper, but with this activity I wanted them to use the extraction of copper to understand the extraction of gold.

(I reflected – this write up will help them do the homework very well. They need the steps from the practical work to do the concept map. Will they know how to do the concept map? They should use their understanding of the copper extraction process steps.)

I did not teach my learners how to draw concept maps. This activity was to test if they join all the relevant points and make their concept maps flow. Concept maps assist teachers to know where their learners are in terms of understanding concepts (Kinchin & Hay, 2000). When analysing data I recognised that my learners drew flow diagrams instead of concept maps. This was because they had to show the process of extraction, so all the steps follow each other in the process. Flow diagrams have some resemblance to concept maps (Davidowitz, Rollnick & Fakude, 2005). Concept maps have linking words and can be complex while flow diagrams are linear and exhibit the procedures. When I was developing lessons I did not know the difference between concept maps and flow diagrams. I could have asked them to draw flow diagrams instead of concept maps. To analyse the flow diagrams, I used the rubric designed by Davidowitz et al. (2005). The rubric has three characteristics, namely structure, applicability and features of diagrams.

- Structure: completeness, appropriate sequencing
- Applicability: relevance of information, evidence of deep processing in translating information from manual to diagram.

There three rubrics of flow diagrams each one is about the characteristics above. I used all three rubrics to analyse three flow diagrams drawn by my learners. The first flow diagram is a sample of the flow diagrams that show learners who had extraction of gold as the central part and all other processes are from the centre. The second flow diagram is sample from a group of learners who drew a flow diagram that has evidence of sequence of steps. The third flow diagram is a sample of the flow diagrams of learners who showed different way of processing the information. Below are the three flow diagrams respectively.

Homework - Chemical Systems

1) To break down the bonds existing within the ore. This also simplifies reactivity.

2) Step 1: Grind the ore into a powder

Step 2: Add Sodium cyanide ($NaCN$) to the ground ore
[$Au + NaCN \rightarrow NaAu(CN)_2$]

Step 3: Heat the "mixture" up to break down the bonds existing within the compound.

Step 4: Before filtering, Wait for it to settle down. Observe the change of colour.

Step 5: Filter the compound out and add zinc as a reducing agent. You will observe that the gold gets deposited.

$3 \times Zn \rightarrow Zn^{2+} + 2e^-$
$2 \times Au^{3+} + 3e^- \rightarrow Au$
$3Zn \rightarrow 3Zn^{2+} + 6e$
$2Au^{3+} + 6e \rightarrow 2Au$
$3Zn + 2Au^{3+} \rightarrow 3Zn^{2+} + 2Au$

3) $NaCN$ → Sodium cyanide
SiO_2 → Silicon

4) * Waste products should be casted underground
* When disposing these wastes, protective gear should be worn

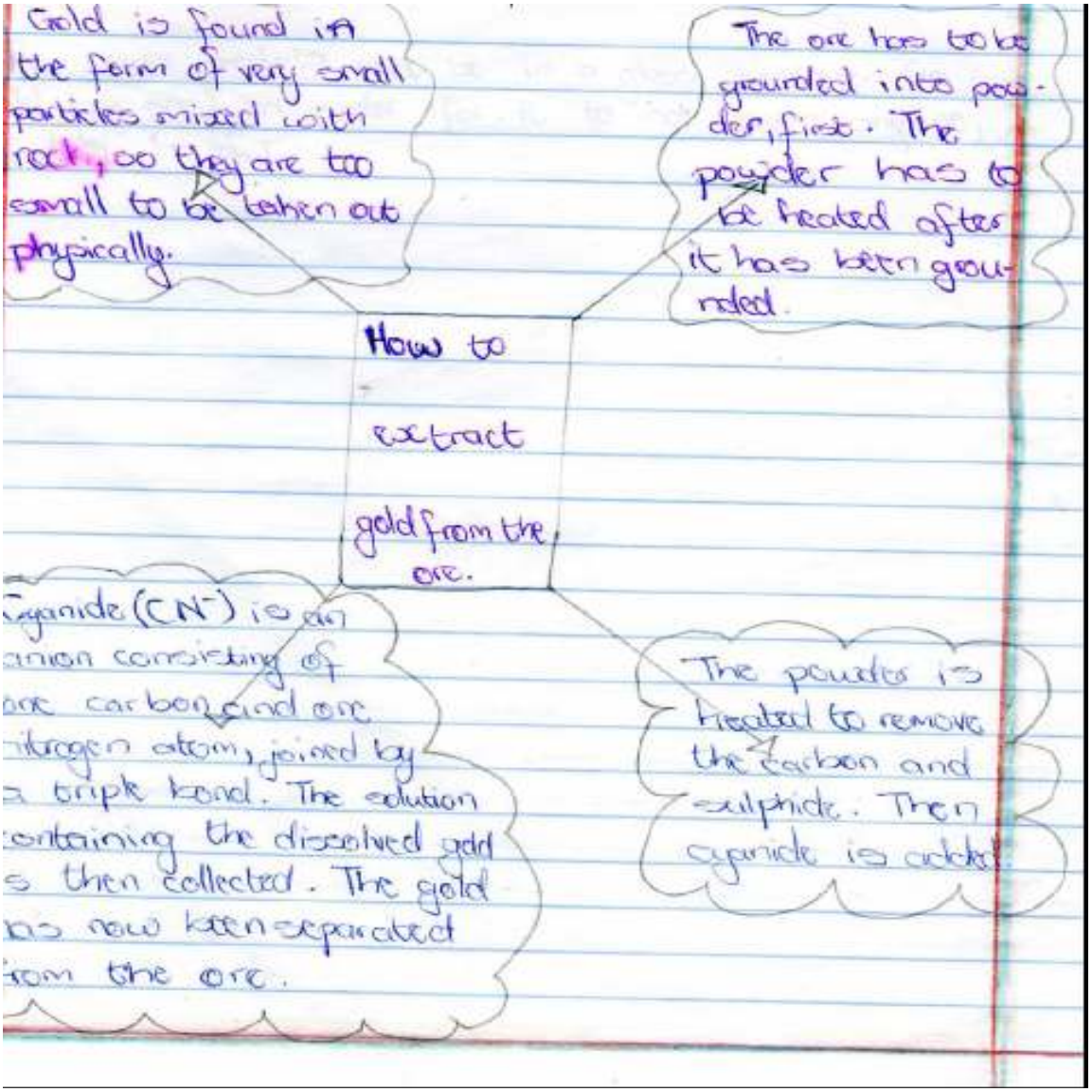
Homework

① Geologists crush the ore rocks to break down the rocks and make the reaction take faster, so that the mineral is extracted much faster than usual.

② 

③ $Au(CN)_2 + Zn \rightarrow Au + Zn(CN)_4^{2-}$

④ THE WASTE CAN BE DISPOSED IN ONE WAY, BY DIGGING DEEP INTO UNUSED LAND AND BURIED DEEP WITHIN THE EARTHS CRUST TIMES AND THE LIQUID DOESN'T CONTENT WITH EVERY POWER. THIS IS LATE ON THE SURFACE MERT COULD MAKE THE REMAINS. SO THEY SHOULD DIG DEEP INTO THE EARTHS CRUST TO IT MUST BE ACT BE DISPOSED IN EARTH SURFACE.


Gold is found in the form of very small particles mixed with rock, so they are too small to be taken out physically.
The ore has to be grounded into powder, first. The powder has to be heated after it has been grounded.
How to extract gold from the ore.
Cyanide (CN^-) is an anion consisting of one carbon and one nitrogen atom, joined by a triple bond. The solution containing the dissolved gold is then collected. The gold has now been separated from the ore.
The powder is heated to remove the carbon and sulphide. Then cyanide is added.

The table 5.2 below show the information from the three flow diagrams.

	Flow diagram 1	Flow diagram 2	Flow diagram 3
Structure	L2 some logic is present but lacks numbering and some sections are missing	L3 key steps present and logical sequencing of steps	L4 all steps present and logical sequencing of steps
Applicability	L1&2 little sign of own voice, no evidence of procedural understanding, no evidence of declarative knowledge (repeated cyanide twice)	L3 some sign of own voice in the diagram, some evidence of procedural understanding, some evidence of declarative knowledge (reducing agent)	L4 own voice evident in the diagram, high level of procedural understanding, declarative knowledge (chemical equations)
Features of diagrams	L2 some incorrect representation	L4 correct representation of procedures	L4 correct representation of procedures

Table 5.2: Information from the three flow diagrams.

From the table above, flow diagram 1shows that the learner had little knowledge about the mining process. He knew that there was an ore which should be ground and cyanide was used in the process. According to Kinchin et al. (2000) a learner who has radial concept map has less understanding. This learner failed to see that extraction of gold is a process where steps need to be followed. Although he was able to do the scientific report correctly because the practical was done in a group, as an individual he did not see the link between the two. For flow diagram 2, the learner understood mining of gold as a process because the steps are in a sequence. There is also evidence of understanding scientific concepts. These were explained in her own voice. Less information was given to learners on the worksheet but this learner was able to use information from the previous lessons.

5.4 My Content Knowledge

In this section I discuss the growth of my content knowledge. The raw untransformed knowledge (CK) needs to be transformed so that it can become teachable knowledge (Shulman, 1986). Transforming knowledge thereby making it accessible for learners is what differentiates expert knowledge from that of the teachers. Since this was a new topic my content knowledge was poor. While I was learning the content knowledge, my beliefs about the earth's crust were being tested. I did not use any specific instrument to capture the growth of my content knowledge. I gathered this information from my reflective journal, collaboration team, lesson development and interviews.

Subject matter knowledge is untransformed content (Rollnick, et al., 2008) which still needs to be transformed for learners to understand that particular topic (Shulman, 1986). I had to learn this material on my own first prior to having meetings with the collaboration team to discuss the big ideas to develop the CoRe. Extracting the big ideas was a challenge to my CK. One of the ideas I battled with was the idea that the earth has a core which is made of magma.

How is possible that the ground is hard and these books say that the core is made of magma? (Journal)

What made things very difficult for me was the fact that I have never studied geography and from a very young age I had told myself the earth is not round.

To be convinced about this I need to read a number of books. I should not only read but for this one I need lot of picture to really change my mind set. (Journal)

I read books from the libraries and went to the extent of going to the geosciences library at Wits. I did not have the knowledge of geosciences and I wanted to know more. So I had to visit this library. After reading several books, I asked myself:

If it took me so long to figure out what the lithosphere is all about then how long is it going to take my learners to understand. Will I be able to deliver???? I must not fool myself I must get

assistance? Why don't I ask Mr. Mnyandu (geography teacher at Forest high school) for help. This will even help me find out what exactly learners know about the lithosphere. (Journal)

The day I met the collaboration team I was confused about what we were going to discuss. We met after I had read material on the lithosphere and gold mining. We met to discuss the Big Ideas in order to develop the CoRe. Although I had read about CoRes and PaPeRs from Loughran's (2006) book, I did not see how what was said was would help me with my study.

What are these Big Ideas they (the supervisors) are busy talking about? I asked a colleague (Miss Fuze) after the meeting. *Do they expect us to know what we intend our learners to know and why even if we don't know the content ourselves. (Discussion noted in the journal).*
Miss Fuze was not able to answer all the questions we had. We were both confused. But she gave me hope. *Maybe it will be better next time we meet.*

As we kept on meeting things became clearer and I started to see how the CoRe was going to help me with teaching of this new content. I realized that at first it was not easy to develop the CoRe because I lacked the comprehension of the subject matter knowledge. "To teach is first to understand, …. when possible, to understand it in several ways" (Shulman, 1987, p14). I could not think of the Big Ideas at that time because I did not understand the subject matter. As Shulman (1987) said that understanding should be in several ways, what I understood at that time was not enough to allow me to see the bigger picture of teaching this topic. He further explains that the understanding that teacher must have should be that of linking the ideas of the topic within the same subject area and also to ideas of other subjects. At that time I did not see science in the topic I only saw the curriculum pushing me to teach what I did not have the knowledge of, which is geography.

Why did the government make us teach this chemical systems? This is not about science but now I am forced to teach geography. Then what are the geography teachers teaching if we have to do their work? These learners have done lithosphere in grade 10 then why now I have to do it again in grade 11. (Journal)

I was really frustrated about this because it seemed as if we needed to teach a repetition of what the geography teachers had done. What scared me most was the fact that the topics taught at lower grades ought to be done in detail in the next grade in the NCS. I did not understand what learners already knew but I was expected to teach it in detail. How was I supposed to do that?

It took a while (three more meetings) to really understand that the Big Ideas are not final and they can be changed as the understanding of the topic improves.

The Big Ideas can be changed anytime you wish to do so. As the understanding of the content knowledge get better the Big Ideas can be sentences rather than one or few words. (Comment from one of my supervisors in the meeting, journal).

Shulman (1987) stated that knowing the content is not what separates the teacher from others but the teacher must have the capacity to transform the subject matter knowledge.

5.5 Conclusion

Transformation of CK is not an easy job but it makes one to use all the knowledge to judge if learners are going to understand or not. The main thing in education is learning more than teaching. How learners' learn depend on how the teacher organise and conduct his/her lessons. Rollnick et al. (2008) model of PCK helped me by distinguishing the teacher domains from the manifestations of teacher knowledge which are more visible in the classroom. Using the manifestations and knowing which teacher domains were responsible for them clarifies the source of PCK.

Chapter 6: Conclusions and Recommendations

6.1 Introduction

In this chapter I discuss conclusions and reflections of the study. This includes summary of research methods, findings and answering research questions. Finally I discuss limitations and recommendations of this study.

6.2 Overview of the Study

This study intended to find out how I transformed and developed my subject matter knowledge when I was teaching gold mining as a new topic to grade 11 learners. I prepared a series of lessons on the topic with the support of a reference group. I collected data using daily journal, group interviews, classroom observation using video recordings and collaboration team. I then created CoRes and PaP-eRs as a way of capturing and portraying my PCK in the classroom. An analysis of my teaching using the Rollnick *et al*. (2008) tailored model for PCK showed how the manifestations of my PCK emerged from my knowledge domains and thus analysed the development of my PCK.

6.3 Critical Reflection of the Study

6.3.1 The Methodology

Since this study is a self study, I kept a daily journal to document all my feelings, thinking, observations and decisions that I had to take as well as changes I made. I found it difficult to write the journal every day because I do not normally keep a diary and keeping a daily journal is like writing a diary every day. I wanted to record how I overcame the fear I had of teaching this new topic. But that was not easy. Some days I did not write hoping I would remember what to write later. I found it time consuming and difficult to write about my feelings. Sometimes I did not know how I felt. This created a problem because it was difficult to remember everything when I was analysing data. As a result, certain important aspects were not documented. Thus I worked with the data I had and tried to recall my impressions at the time to supplement the journals. This resulted in gaps which were difficult to fill and may have created discontinuities in the data.

The transformation of subject matter knowledge is the main concern of this study. CoRes and PaPeRs (Loughran et al., 2004) were used to capture and portray my PCK. The prompts from CoRe template assisted in making me think deeper into my PCK as I was preparing the lessons. The PaPeRs helped in putting life into the ideas I had during developing the CoRe. PaPeRs, which is portrayal of actual teaching brings reality to the planned lessons where learners can show whether they understood or not. The CoRe helped with the transformation of content knowledge and PaPeRs helped with capturing its manifestation in the classroom.

Another factor that contributed to the successful construction of the CoRe was having a colleague who was doing a similar study. Together we were able to enrich the CoRe with the input of the collaboration team that consisted of our supervisors and another masters' student. This process was valuable because for us to agree about one Big Idea we first had to discuss it and look at the factors that make it a Big Idea. Everyone was given a chance to contribute. This made me feel accommodated and part of the team; since I was a teacher I thought only the supervisors could have a say. I was able to voice my beliefs and misconceptions about the shape of the earth and magma. The team never looked down on me but they were supportive from development of the CoRe, lesson planning, data collection and data analysis.

Capturing my teaching on a videotape helped a great deal because I was able to see how I taught and I was able to replay it over and over again to see classroom management, learners' attitude during the lessons and other aspects of my teaching. Although it was not possible to video record all the lessons due to the fact that I was using a colleague to operate the camera, I was able to see the process from the lessons that were captured. Even though some of the lessons were too noisy to capture dialogue, I was able learn from the body language of learners and the general course of the lesson. The video recording helped to answer the question on how I transformed my knowledge while teaching the content.

Hitchcock and Hughes (1989) say that the classroom is a very complex social situation. There are many things that happen in a classroom during the lesson and many factors can be learned from that situation. I used both video and audio recordings. Video recordings record both verbal

and non-verbal human behaviour on the physical environment (Opie, 2004). There I needed to see movements, facial expression, gestures etc. Altricher, Posch and Somekh (1993) say that this assists in detecting confusion and learners' understanding. Because I was teaching my own learners, I was able to detect when they did not understand. But there were technical problems with the video. As mentioned above, the noisy interactions of learners while doing activities made it difficult to capture their discussions. As Opie (2004) said, videos can have technical problems, such as sound. As a researcher I needed to be cautious about relying on technological apparatus.

Rather than focussing on learning, I was preoccupied with learners not completing the practical work. It is impossible for an individual to record everything (Opie, 2004). I think it would have had more data if I could have video recorded each group. I did not get what was discussed when the video camera was not focusing on them.

The learners' assessment assisted with analysing learners' understanding of concepts. Here there was clear distinction whether some learners understood the work on flow diagrams or not because I did not know the concept maps. Most of the learners drew flow diagrams because they were illustrating a process of extraction of gold. I learnt about concept maps when I was analysing the data. This gave me an idea that flow diagrams are not the same as concept maps. I wanted them to draw flow diagrams but concept map confused some of them. However I was able to find some flow diagrams I used to analyse.

6.3.2 Discussion of the Findings

Difficulties related to the relationship between CK and constructing Big Ideas for the CoRe

Curriculum change posed a big challenge to me as a teacher, especially the introduction of new topics that were unfamiliar to me. I did not have the courage to teach gold mining as a new topic in grade 11. I felt scared because I did not want to make a fool of myself in front of learners. Doing a self study made me learn more about myself and from the collaboration team. I had to study the new content several times before trying to work with it. I looked at CK and PCK in a

transformative way. According to Kind (2009), transformation of CK (PCK) comes after understanding CK.

After understanding the new content, I started making the CoRe with the collaboration team, then design lessons to teach. The difficulty for me was not grasping it. By reading it several times, I wanted to understand it using different angles. At times these angles did not meet. I could not see the bigger picture. As I was trying to get the bigger picture I wanted to think of teaching strategies. These teaching strategies did not come easily because the content knowledge was lacking. This is the reason why Shulman (1986, 1987) emphasized the importance of CK, because without the CK one cannot have a good PCK. I found it difficult to think of examples that I could use when teaching this topic. I had the curriculum document and books to read but these did not help at that time. This really frustrated me. What made it difficult was that when I first learned about gold extraction and the lithosphere, it was very difficult for me to understand. The types of different rocks containing different minerals and what formed them were a big problem for me.

I also encountered problems thinking of the Big Ideas for making the CoRe since my CK was not good. On my own it would have taken me longer to come up with Big Ideas, but my collaboration team assisted greatly. This shows that it is possible for one not to have good Big Ideas due to lack of CK and as time goes on as the CK get better the old Big Ideas can be replaced by new ones. I struggled with the understanding of the Big Ideas and even after our collaboration meetings I still had problems. In the first meeting our homework was to go and think about the Big Ideas after they were explained to us as the main things that will help learners to understand the topic better. When we met for the second time these Big Ideas were fleshed out. But still I did not know what was important for this topic because I had no understanding of what was important and what was not. As shown in the data analysis, my colleague assisted me greatly with this process.

I later found out that Big Ideas can change; depending on what one thinks is the main idea at that time. This made me start to understand these Big Ideas, because I was wondering what if I did not come up with these main ideas that were discussed in the second meeting. It also clarified that my Big Ideas can be different from the other teacher's Big Ideas even if we were planning to

teach the same topic. These ideas depend on what the teacher think is important at that time. The Big Ideas are the first thing one has to come up with be when constructing the CoRe. When one has them it is easy to continue. It was at this point that the CoRe started to lay its foundation in my mind. Thus the construction of the CoRe was a slow, iterative process, resulting in a CoRe that was dynamic and growing during the study.

Designing the Lessons

Even the CoRe did not help with all the CK that I did not understand. It helped in giving light on how to treat old and new topics. As a result I started teaching this topic with little confidence. Knowing some of the learners' prior knowledge and context helped in the designing of lessons. In the lessons I included concepts I did not understand to allow myself to learn together with my learners. It took me time to grasp the lithosphere and the history from Stone Age to Plastic Age. I included them for learners who had better understanding of things to help those like me who took time to understand. I expected learners to ask questions about iron or copper age and how those people knew what to do. I did ask myself this but I did not find answers from books.

The books I read said that these people extracted minerals by heating them in underground ovens and the minerals were moulded to different shapes. I needed to know how they came to know what those rocks of ore contained. It interested me that the learners did not ask that question. I taught without knowing the answers to my question but it was bothering me and I kept on thinking about it. After I finished teaching, I thought that these early miners could be considered to be scientists in their own right through their discoveries. This shows that one does not stop reflecting on what I could have said, done and prepared for a lesson. More light came after teaching the lessons and looking at the whole study and how I got assistance from people. While I was teaching I had too many doubts not being sure whether what I was doing would benefit my learners or not. This reminded me of my first year of teaching. I found it difficult to teach because my heart was always pounding. I learnt that lesson development is an ongoing process.

Through the study I developed a great interest in mining and I read newspaper articles about mining. What I find most interesting is how illegal miners extract minerals without the industrial equipment.

The Importance of Records

As mentioned above, I felt like journal writing was a burden. During one of the collaboration meetings I asked the supervisors if it was necessary to keep a journal. One of them said that it was very important because I would forget some of the things that happened. No matter how small they may be, everything needs to be written down. I continued writing the journal but not every day. I tried to write every second or third day. As I wrote, I realised that what the supervisor said was true. When writing a research report some of the small things that occurred were missing because even in writing I was not good at recording all the details.

I really started keeping the journal while I was studying the CK. I did not have much to write. My early reflections showed that I often recorded events without the surrounding detail. For example, I did not explain why I went to the geography teacher and what we discussed. Why was I given a grade ten geography book? I tried filling in the gaps after the study thinking back on what was going on in my mind. I was forced to think about the things that led to certain events like the fact that I was given the geography book because geography learners started the lithosphere in grade ten. What I cannot remember is what I discussed with the geography teacher. And I do blame myself for that.

When I started teaching, writing the journal improved because I felt a need to explain what frustrated me during the lessons. I did not focus much on the good things, but mainly what I should improve for the next class. Although I lacked confidence in writing the journal I wrote more than before when I was teaching. At that time I forced myself to write almost every day because to me the real study was the period when I was teaching. I did not think that the things that occurred when I was learning were important. Now reflecting on the whole study I can write more.

Lesson Design and Teaching Process

I designed the lessons myself so when things went wrong during the lessons I could blame only myself. As part of the research, I asked learners what they thought of my lessons, something I had never done before. They expected my lessons to be exciting and they commented that I should have used soil as part of the lithosphere lesson. I had expected my collaboration team to

help me with the design of the lessons. Though they gave me support, they did not see any faults with the lessons, pointing to their lack of PCK in the area. When problems arose in class, I asked myself why they had not picked it up, when they saw the lesson plans. During the study I was disappointed that they could not foresee the problems. Later when I reflected on the whole study I was grateful to them for not modifying the lessons. I would need to understand changes they made and at the early stages I would not have appreciated the need for them. The learners' questions required answers which required me to improve my understanding of chemistry. Hence one can be exposed if the lessons and CK are not well understood. This has also prepared me for the future that a lesson cannot be perfect. One has to keep on changing lessons depending on the type of learners one has and what needs to be taught. I thus drew two important lessons from the study. Firstly, that it is difficult for teachers take on board constructive comments unless they are ready. If they are not ready, the comments will not find fertile ground.

Secondly, it takes a great deal of adjustment to accept learner criticism, but when the adjustment has been made, it is an important factor in improving teaching. My collaboration team made me survive the criticism I got from learners. It was not easy for me to do the study but through their support I was able to move from one level of knowledge to the other. They were my pillar of strength. Before this study I did not allow anyone to criticise me or my work. I knew I was not perfect but I thought no one had the right to criticise. They kept on telling me to look on the positive side about whatever was said and I did. I was able see my mistakes and made sure I do not repeat them. Now I allow people to criticise me, even in teachers' meetings I do not get angry when one says something about my comment or work.

For all the years that I have been teaching I have been using a traditional method of teaching. I generally spend a large part of the lesson writing on the board and explaining work to learners. At the end of the day, my hair, clothes and shoes are full of chalk. However, for this study I made up my mind to change and become a facilitator. The idea of facilitation in the classroom in South Africa was encouraged when C2005 was introduced. Teachers were told that they do not teach anymore and learners are the ones that do the work in class (Rogan, 2004). To me facilitation was about letting learners learn on their own and the facilitator is to assist or guide them during their learning.

After designing the lessons, my colleague and I were invited to conduct teachers' workshops on our lessons as most teachers like us lacked confidence in teaching these topics. Conducting these workshops was another contributing factor to my confidence. When I answer other teachers' questions in a way that satisfies them, I feel great.

6.4 Summary of the Findings

The aim of the study was to examine how I learn and teach gold mining to grade 11 learners, which is a new topic in the new curriculum. This section presents the research findings and attempts to answer the research questions of the study.

6.4.1 How do I Transform My Content Knowledge in order to Teach Gold Mining?

Shulman (1986) argued that a teacher is an individual who transforms knowledge and makes it accessible to the learners. Bishop and Denley (2007) stated that PCK is the knowledge which combines other knowledge. PCK is the knowledge the teacher has to make CK accessible to learners. Shulman (1987) further argued that within PCK there are domains of teacher knowledge which together with the manifestations of teacher knowledge form the PCK of the teacher. PCK is the blending of colours to form a white, which is different from the colours that constitute it (Bishop & Denley, 2007). PCK is when the domains of teacher knowledge are put into practice in forms of manifestations of teacher knowledge.

Teaching is not an easy task. According to Shulman (1987), teachers have to transform the content knowledge to make it accessible to learners. The prompts from the CoRe template (Loughran et al., 2004) helped me transform my content knowledge. The prompts gave me guidance on what are the Big Ideas I wanted learners to learn about gold mining and the key things I wanted them to understand and why. The collaboration team assisted me by explaining the concepts I did not understand. I used the transformative PCK (Kind, 2009) because for me content knowledge is separate from PCK. Transforming CK was done using the teacher domains from Rollnick et al.'s (2008) model. Using their science prior knowledge helped me design lessons that allowed me to learn to be a facilitator. If my learners did not know oxidation numbers and electrochemistry, my lessons would have been different.

6.4.2 How does My Understanding of the Relevant Content Change as I Teach?

Learners taught me to understand gold mining from the geographical point of view as well as in a science way. From the beginning of the study they were really excited and were looking forward to new things. Although they were bored in the first lesson because the practical work was not exciting for them, they used their geography knowledge of what the lithosphere was. When they asked me about the soil as part of the lithosphere, they wanted me to link their geography knowledge with the science one. They made me think more about the lithosphere not only what I wanted to teach them but what it is. When I designed the lessons I concentrated on the rocks since they are ones that contain minerals. I never focused on the soil and by bringing soil up in the lesson, it taught me that dealing with concepts that learners have prior knowledge a teacher must explain why certain parts of that concept are not used.

6.4.3 What are Some Challenges Influencing the Way I Learn to Teach Gold Mining?

Learning about the lithosphere was more challenging. I did not do geography at school. I had a problem with understanding the shape of the earth. Learning this topic challenged my beliefs such as the shape of the earth. I do not see earth round as books and other people say. According to me, the earth is a flat surface. I was forced to teach something I do not believe. The knowledge that my learners had done the lithosphere in grade 10 did put me at ease. I knew that I was going to learn from them. In the lessons that I developed, I did not include the shape of the earth, but I did include the diagram of the earth. My openness to the collaboration team about things that were hindering my learning helped a lot because they were able to conceptually change my misconceptions.

6.4.4 What is the Impact of the Learners' Prior Knowledge on the Way I Teach?

In this study, I made a conscious decision not to teach this topic but rather to be a facilitator, as required by the new curriculum. I had never facilitated before as my normal practice was to use teacher centred methods. When the curriculum 2005 was initially introduced, it affected the lower grades and at that time I was teaching grade 11 and 12. I was expected to teach by facilitation from the beginning of 2007 when the new curriculum was introduced to grade 11. I was able to continue with my traditional methods because I knew my learners would cope since they were learning concepts we had dealt with before. They were dealing with the lithosphere

which had been taught in grade 10 geography. My learners knew about the lithosphere because they asked me why I did not use the soil as part of my experiment about the lithosphere. They caught me unaware but I answered them by saying that some particles from the soil dissolve in water so that would have caused confusion to some learners. That is how I justified my decision, despite the fact that it never crossed my mind to use soil. I used my experience of teaching science for quite some time. Bishop and Denley (2007) argued that learners need to listen to see that they also have a say in their education. According to Hatano (1996), learning occurs when the existing knowledge is restructured in order to allow the new knowledge to fit it. They needed to understand lithosphere better using both from a science and geography point of view. The knowledge structure that existed before were restructured to accommodate the new scientific knowledge.

The role play (see Appendix D lesson four) is the play done by learners acting the roles of the people they are learning about. Learners felt very important and really acted as those people. Learners' excitement went on for a while because some of them were unhappy about the decisions their mayors took. The debate continued even after class and I told the learners to calm down as these were just roles they were acting. This activity made quiet learners to be vocal and discuss scientific concepts. Their actions made me see that teaching in a traditional way suppresses learners' ideas about science. They leave the classroom with knowledge that their ideas will work. But if they were given a chance to voice out their ideas they will have heard different views from other learners. Debating and defending their ideas taught them about real life situation where an individual is not always right. For me I had changed the way I teach, I did not do 180 degree turn but I do have some lessons where they can have such debates or even to present their research projects.

6.5 Limitations of the Study

Data collection was done at the appropriate time from learning the content knowledge during the third term to teaching the topic in the fourth term. Knowing what learners knew made me plan the lessons the way I did. If I was not at my school and teaching my own learners I would not have collected the data I had. My study was a qualitative self study. I was researching about my own teaching practice and used my learners as the subjects. The findings of this study cannot be

generalised, but they can make one have ideas on what is happening to the teacher in my situation.

6.6 Recommendations

Next time when the government changes the curriculum, the policy makers must ensure that teachers have good content knowledge to teach the new topics. When workshops are done, experts from universities must teach those topics. Teachers need to know the meanings of terminology used by that curriculum. For example, most teachers do not know what facilitation means and it was used incorrectly in Rogan's (2004) study. I was surprised during my study when learners needed more knowledge than what I had prepared for them. For most teachers, facilitation is about moving around making sure that learners are doing work.

The South African government is changing the curriculum once more after the NCS. The new document to replace NCS is called Curriculum Assessment Policy Statement (CAPS). "The CAPS are single, comprehensive an concise policy documents to replace the current subject and learning area statements, learning programme guidelines and subject assessment guidelines for all subjects listed in NCS for Grades R to 12" (DoE, 2010). They have changed the curriculum in a way that some of the new topics are now excluded from the curriculum. Mining is optional. This is demotivating me as a teacher who had done research on this topic so as to teach it better. All that energy and time wasted to learn this topic that is no longer important for some people is what makes me as a teacher demotivated. Why was it included in the first place if now they do not see its importance? Mining is important for learners to know since it makes us understand where our economy comes from. These are some of the things that make teachers not to be prepared to learn new topics because the government will remove those topics when they are difficult for teachers. If they had planned it very well before the implementation of NCS this would have not occurred.

6.7 Directions for Future Research

Further self study research can be done by teachers who have difficulty in teaching certain topics within the science curriculum. Science educators can ask student teachers to do research on the

topics that were difficult for them when they were at school. Even if it is only a concept because it is not necessarily that it must be the whole topic. It will be interesting to find out how teachers design lessons and teach those concepts. This will decrease the number of science teachers who cannot teach certain topics. When the teacher likes physics more than chemistry, he/she may be asked to do a research on the most difficult topic in chemistry. This poses a threat to science teachers when we have to teach both physics and chemistry at school as physical science.

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Appendix A_1 – Consent letter

Dear Principal

Re: request to do a research at your school

Research Project:

Facing the challenge of learning and teaching gold mining Grade 11 in the new curriculum: a Self-study

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 gold mining as a new topic for the new curriculum.

The study entails me having a normal class lesson with the learners, which will be video recorded. The will be a group interview immediately after the lesson and one on one interviews sections conducted thereafter. 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 this topic of mining 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

(Mrs M. Ndhlovu)

_____

Appendix A_2 – Consent letter

04 September 2007

Dear Parent/Guardian

Research Project:

Facing the challenge of learning and teaching gold mining Grade 11 in the new curriculum: a Self-study

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 gold mining as a new topic for the new curriculum.

The study entails me having a normal class lesson with the learners, which will be video recorded. The will be a group interview immediately after the lesson and one on one interviews sections conducted thereafter. 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

Mrs Majabulile Ndhlovu

_____

Appendix A_3

Informed Consent Form: **Parent/Guardian**

Research Project

Facing the challenge of learning and teaching gold mining Grade 11 in the new curriculum: a Self –study.

I _____, parent/guardian of my child/ward _____ consent to her/him participating in the study conducted by Mrs M. Ndhlovu of XXX High 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. YES NO

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

I allow my child/ward to be audio 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: _____

Appendix A_4

Informed Consent Form: **Learner**

Research Project

Facing the challenge of learning and teaching gold mining Grade 11 in the new curriculum: a Self –study.

I _____, grade11 physical science learner agree to participate in the study conducted by Mrs M. Ndhlovu of XXX High 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

STUDENT NUMBER: 9113152Y

Protocol: 2007ECE58

Mrs Majabulile Ndlovu
11790 Mtipa Street
Orlando West ext
P O ORLANDO
1804

Dear Mrs Ndhlovu

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:

Facing the challenge of learning and teaching gold mining Grade 11 in the new curriculum: a self study

The following comments were made:

- While the submission states that GDE approval has been sought, this is absent from the submission itself.
- The subject information sheet needs to be more comprehensive and should stipulate the nature of the project, limitations of anonymity and confidentiality, as well as date destruction procedures after completion of the study, especially given the data collection methods employed.
- Furthermore, informed consent must be separately obtained for participation, audio-recordings and video- recordings from parents and learners alike.
- In addition, the candidate needs to consider reworking the closed questions to learners, and to convert these to more open ended formats.
- The need for video recording has not been substantiated. The necessity for using video recording in the research needs to be clearly justified.

Recommendation:

This is a minimal risk study that requires technical adjustments in order to comply with ethical

standards. Therefore, accept and proceed, after integration of the recommendations to the satisfaction of the supervisor.

The supervisor needs to inform the office of the Wits School of Education's Research Ethics Committee that the above mentioned amendments have been made to the proposal for ethics clearance to be granted.

Yours sincerely
Matsie Mabeta
Wits School of Education
Cc: Supervisor: Prof. M Rollnick (via email)

Appendix C – My Reflective Journal (Sample)

Dates	What happened?	How do I feel about it?	What did I learn?	What can I change or do differently?
20/07	-Developing the CoRe (Big Ideas) for gold and coal. -What is available? -How is it made available? - -To make my journal flow -Do it on regular basis	-At first 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 from us. -After few minutes Marissa explained what are big ideas. This gave me a little bit of confidence. She said that it is possible to do the CoRe even if there are question that we cannot answer right now. Things like things to leave out and limitations/difficulties that learners can have. -	-Big ideas are not the best ideas and they can be changed at anytime depending on the new information. -Significance is not the same as important. -	-To be positive about this CoRe because it will help me to structure my lessons correctly. -
27/07	-cont. filling the CoRe (choosing the best suitable ideas). -given internet notes by Mpunki -explanation of 1. what money is 2. different types of coal 3. importance of gold endurance and density. - clarification on energy and social issues.		-choosing the most suitable idea confirmed Marissa's point of CoRes can be changed at anytime. -Rich people used different type of coal from ours. -More energy is liberated from the top coal than the one we used in the townships.	

15/08	-To design lessons using Dr. Vhurumuku's method -not to be scared to ask learners different and difficult questions -start with easy questions to difficult in order to cater for learners with different abilities to answer questions -To decide whether I want to use LO1 or LO2 for my first lesson. - find a teacher to videotape my lessons or another to observe – validity of the research. Especially if I get feedback from both of them. To be careful not to disrupt the school. -to practice the teaching method before doing the research, so that learners are not surprised and end up doing funny things.	I felt really bad and lost about my lessons.	LO1-practical, recipe type, done in grade 10. LO2-investigation, hypothesis, changing variables, done grade 11, no method of doing things. This was an eye opener that I do not know Los and therefore I cannot just use them anyhow.	Change the practical to suite the grade 11 and the questions should be complementing the practical.
23/08	-Know how do you expect learners to find the answer to questions in the worksheet. -give clear instructions if learners have to read an extract form the newspaper or use school's textbook to		-Energy never gets used up. Energy is not a substance but it is converted from one form to another. There are only 2 types of energy potential energy and kinetic	

	get answers from. -look for learners reasoning support materials like internet can be used -from the textbooks find relevant text that one wants to use. -there must be a storyline in the worksheet. -Mpunki discussed a certain method of researched done in Cape town that we can adopt their style for to look at how we can complete the other sections of chemical systems.	-Good idea and different approach from the way we are going to teach the other sections. But this is then broadening the research from teaching gold only to the whole section on chemical systems.	energy. -research is the process I am going through not developing the lessons. -for the woprksheet I must use arial not times roman and a bigger font. 1,5 spacing especially where learners have to answer questions.	
28/08				

Appendix D – Lesson Plans

Lesson one

Grade 11 Physical Science Chemical Systems

Introduction to Lithosphere

Teacher's notes

NB. Lithosphere was taught in grade 10 geography.

Major idea

The lithosphere is the outermost part of the Earth and is made up of different elements and has different chemical compositions.

Key concepts

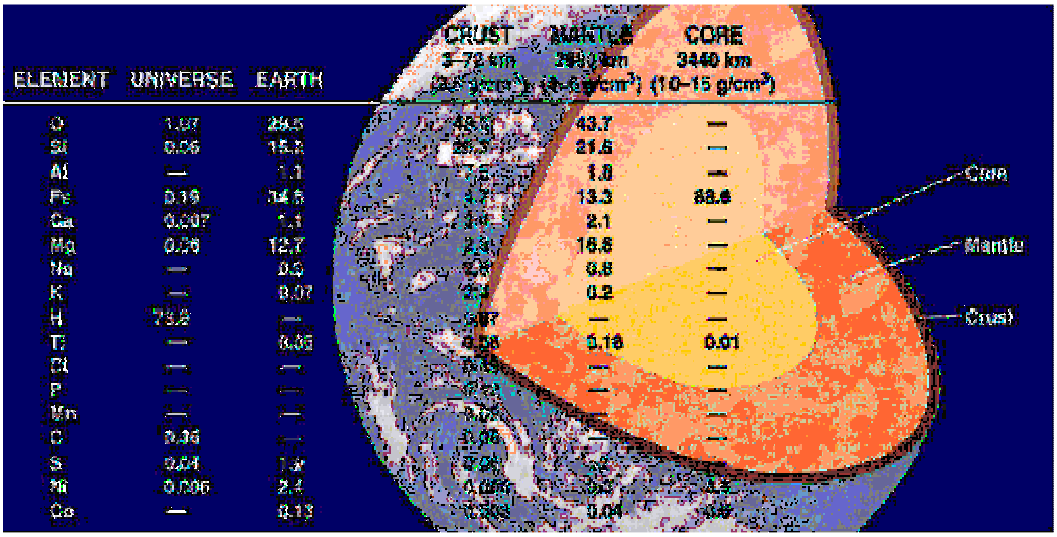
Lithosphere, mining

Unit objectives

- From the practical learners must be able to identify that the substances given to them have different chemical compositions viz. intermolecular forces and types of bonds. The strengths are not the same.
- Lithosphere has an uneven distribution of elements (minerals) due to the different chemical composition of that particular area (region).
- The purpose of mining is to find the precious elements that are embedded in the lithosphere (separating minerals).
- Learners must be able to link technology and the different ages that happened long ago.

Basic Content

Lithosphere is made up by the upper mantle and the earth's crust. It has different elements which are differently combined.



-

-

-

Chemical Systems

Grade 11

Exploiting the lithosphere

Work in groups

1. Each group has five different substances (A-E) and two solvents X and Y, test tubes and test tube rack, rubber stoppers and iron nails.
2. Use your fingernails to scratch each of the substances. If it does not get scratched used the iron nail provided to scratch them. (DO NOT TASTE)
3. Put few crystals of each substance into the test tube. Add solvent X in each test tube.
4. Repeat number 3 using solvent Y.
5. In the space provided give reason(s) what causes your observation(s).

-

-



Worksheet (LO2) (AS3)

	Substance A	Substance B	Substance C	Substance D	Substance E
How does it look like?					
Reason(s)					
Fingernail					
Reason(s)					
Iron nail					
Reason(s)					
Solubility in solvent X					
Reason(s)					
Solubility in solvent Y					
Reason(s)					

Activity (20 minutes)

Resource materials given to each group: grade 11 physical science textbooks, oxford science dictionary, geography textbook about the earth, atlas and English dictionary

(a) Why do these stones react differently in different conditions?

_____

_____

_____

(b) What makes them different from each other?

_____

_____

_____

(c) Do you think they are found in the same place? Justify your answer.

_____

_____

_____

_____

(d) What is the Stone Age?

_____

_____

_____

(e) Why is it important for us to know about the Stone Age?

_____

_____

_____

_____

(f) How did Iron Age bring about change in human life?

_____

_____

_____

_____

(g) What is the lithosphere? Where is found on earth?

_____

_____

_____

(h) Do you think the lithosphere has anything to do with the types of stones we have used before? Justify your answer.

_____

_____

_____

(i) What are minerals?

_____

_____

(j) What is mining?

_____

_____

(k) What is open cast mining and underground mining? Why are these two types of mining different?

_____

_____

(l) Does technology affect mining? (How)

_____

_____

_____

(m) Is mining important for us?

_____

_____

_____

_____

_____

_____

_____

_____

_____

Report back (15 – 20 minutes)

Teacher's notes (L03)

NB. Lithosphere was taught in grade 10 geography

- From the practical learners must be able to identify that the substances given to them have different chemical compositions viz. intermolecular forces and types of bonds. The strengths are not the same.
- Lithosphere has an uneven distribution of elements (minerals) due to the different chemical composition of that particular area (region).
- The purpose of mining is to find the precious elements that are embedded in the lithosphere (separating minerals).
- Learners must be able to link technology and the different ages that happened long ago.

Homework Exercise

Periodic table (electron configurations)

Electron configurations of the neutral gaseous atoms in the ground state.

	1 H																													2 He
1s:	1																													2
[He] +	3 Li	4 Be																					5 B	6 C	7 N	8 O	9 F	10 Ne
2s:	1	2																					2	2	2	2	2	2
2p:	-	-																					1	2	3	4	5	6
[Ne] +	11 Na	12 Mg																					13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
3s:	1	2																					2	2	2	2	2	2
3p:	-	-																					1	2	3	4	5	6
[Ar] +	19 K	20 Ca														21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
4s:	1	2														2	2	2	1	2	2	2	2	1	2	2	2	2	2	2	2
3d:	-	-														1	2	3	5	5	6	7	8	10	10	10	10	10	10	10	10
4p:	-	-														-	-	-	-	-	-	-	-	-	-	1	2	3	4	5	6
[Kr] +	37 Rb	38 Sr														39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
5s:	1	2														2	2	1	1	2	1	1	-	1	2	2	2	2	2	2	2
4d:	-	-														1	2	4	5	5	7	8	10	10	10	10	10	10	10	10	10
5p:	-	-														-	-	-	-	-	-	-	-	-	-	1	2	3	4	5	6
[Xe] +	55 Cs	56 Ba	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
6s:	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	2	2	2	2	2	2	2
4f:	-	-	-	1	3	4	5	6	7	7	9	10	11	12	13	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
5d:	-	-	1	1	-	-	-	-	-	1	-	-	-	-	-	-	1	2	3	4	5	6	7	9	10	10	10	10	10	10	10	10
6p:	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	3	4	5	6
[Rn] +	87 Fr	88 Ra	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Uub	113 Uut	114 Uuq	115 Uup	116 Uuh	117 Uus	118 Uuo
7s:	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2														
5f:	-	-	-	-	2	3	4	6	7	7	9	10	11	12	13	14	14	14														
6d:	-	-	1	2	1	1	1	-	-	1	-	-	-	-	-	-	-	2														
7p:	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-														

Chemical series of the periodic table

Alkali metals	Alkaline earth metals	Lanthanides	Actinides	Transition metals
Poor metals	Metalloids	Nonmetals	Halogens	Noble gases

- Grayed out electron numbers indicate subshells that are filled to their maximum.
- Configurations of elements with light gray background are uncertain or not available.

Configurations that are unavailable are guessed to be similar to the element directly above on the Periodic Table.

- The bracketed noble gas symbols on the left represent the inner configurations that are the same in each period. Written out these are:

  He, 2, helium : $1s^2$
  Ne, 10, neon : $1s^2\ 2s^2\ 2p^6$
  Ar, 18, argon : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$
  Kr, 36, krypton : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6$
  Xe, 54, xenon : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^6$
  Rn, 86, radon : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^6\ 6s^2\ 4f^{14}\ 5d^{10}\ 6p^6$

- *Note the non-linear shell ordering, which comes about is due to the different energies of smaller and larger shells.*

Use the information provided to answer the following information.

1. Write down the electron configuration of: copper, silver and gold.
2. Write down the Lewis structure of gold.

Lesson two

Gold as an element and gold mining (introduction)

Teacher's notes

Major idea

Key concepts

Unit objectives

- Start by explaining the homework by showing them what they were supposed to do.
- From the homework they will their understanding to answer the worksheet.
- Aim of this activity is to understand why gold is mined differently is due to its properties.
- This activity combines both the historical background of Johannesburg and the both physical and chemical properties of gold.
- Learners must discuss the environmental impact of mining even if we are benefiting from gold.

Basic Content

Chemical Systems

Grade 11

Gold as an element and introduction to gold mining

Groupwork

Groups to be given the same resource materials from the previous lesson.

Activity (20 – 25 minutes)

1. Compare the density of gold and copper.

_____

_____

_____

_____

2. Compare the properties of gold and copper.

_____

_____

_____

_____

3. What are the uses of gold?

_____

_____

_____

_____

_____

4. What is the gold rush? Why is it important for us to know about it?

_____

_____

_____

_____

_____

_____

_____

_____

5. What is gold panning?

_____

_____

_____

_____

_____

6. Does gold mining have any environmental impact?

_____

_____

_____

_____

_____

Report back (10 – 15 minutes)

Lesson three

The process of mining gold

Teacher's note

Major idea

Extraction of gold

Key concepts

Ore, crushing,oxidation and reduction.

Unit Objectives –Learners need to understand the simplest way of extraction.

NB. Do little bit of revision of oxidation and reduction especially the oxidation numbers.

Basic Content

Ore is the raw mineral.

Crushing is grinding of rocks.

Oxidation is the reaction when a substance looses electron(s).

Reduction is the reaction when a substance gains electron(s).

Learners' activity

Work in groups

Imagine that you are miners and that the sample given to you has metal. You do not know how to extract the metal. Discuss and plan how you are going to obtain the metal from your sample.

Your apparatus are:

- A Bunsen burner
- Dilute sulphuric acid
- Copper compound mixed with sand
- Two beakers
- Funnel
- Filter paper
- Zinc powder/granules

Lesson three

Homework

In today's investigation you extracted copper from its ore. Use the same process and suggest how gold can extracted.

Gold is unreactive, it does not react with sulphuric acid. Sodium cyanide (NaCN) solution is the solvent used to loosen the gold from the rock. Together they form sodium aurocyanide, which contains Au^+ ions. Iron or zinc are the metals used as reducing agents.

1. Why do geologists crush the ore before adding chemicals?
2. Imagine that you are the chemical engineer who has been appointed to extract gold from the ore. Write down an explanation of the process for the mineworkers so that they will understand what they are required to do. (Mind or concept map can be used to show the steps).
3. Write down the names and formulae of substances present in the waste material. (add these in the concept map).
4. Suggest a plan of dealing with the waste as safely dispose harmful substances.

Read the following article:

Jo'burg Gazette, 15 September 2007

Reef mine to reopen

In 2005 this mine was closed down due to the death of eight mineworkers who were trapped underground for than twenty-four hours. Investigations proved that the accident occurred due to negligence of the mine management ignoring some of the safety rules for the miners. While nobody was taking care of the mine sodium cyanide spilled into Manu stream in the southern region of the city. Few days later thousands of fish were found floating in the river. Now under new management the mine is about to reopen and they promise to use new safety methods and really take care of the mineworkers.

Lesson four

The big debate in Goldville

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 highest producing gold mines in South Africa. People rushed to Goldville and established good infrastructure and facilities. However, in the 1970s the mine had to be closed because it was no longer economically viable.

A few years after the mine closed, a young boy fell down the abandoned mine shaft and died. People became 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 Goldville Theme Park. Many of 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 close 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 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: 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 estate agents and super-markets, support MicroGold's proposal. But the members of the tourism industry, e.g. owners of hotels, guesthouses and restaurants are opposed to the proposal.
Group 3: 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 only bring environmental pollution, increase crime and other problems.	**Group 4: Citizens for Economic Growth** These young professionals are in favour of the re-opening 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, the infrastructure will improve and new business will emerge.
Group 5: 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 environment track record. A few years ago they were fined when a large amount of cyanide leached into a river, due to the company's negligence.	**Group 6: Town council 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.

Appendix E – Learners' written work

Chemical Systems

Grade 11

Gold as an element and introduction to gold mining

Groupwork

Groups to be given the same resource materials from the previous lesson.

Activity (20 – 25 minutes)

1. Compare the density of gold and copper.

Elements of Gold are much more than that of Copper which gives it is weight and density

2. Compare the properties of gold and copper.

Gold is shinner than Copper whereas Copper is much more ductile. Gold is dense and Copper light

3. What are the uses of gold?

Gold has a variety of uses. It could be used for jewelery or an astronauts visor for it is a good or the best metal which reflects infra-red rays.

4. What is the gold rush? Why is it important for us to know about it?

Gold rush is part of the history and part of the present where people are told about a certain place where gold is found. the they will rush to the place to try and mine the mineral

11

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Chemical Systems

Grade 11

Gold as an element and introduction to gold mining

Groupwork

Groups to be given the same resource materials from the previous lesson.

Activity (20 – 25 minutes)

1. Compare the density of gold and copper.

Gold is much more heavier than copper
the atomic mass is heavier than copper

2. Compare the properties of gold and copper.

Copper properties	Gold properties
• flexible	• metal, malleable
• dull	• shiny
• conducts electricity	• conducts electricity, heat

3. What are the uses of gold?

Jewellery, mass

4. What is the gold rush? Why is it important for us to know about it?

Gold rush is when many people want to mine to get the gold for them selfs like the first time gold was descoved every one wanted it but didn't have the proper equepment to do the job but did it any way. So our country would not be exploited so they would be enough Gold for us to export

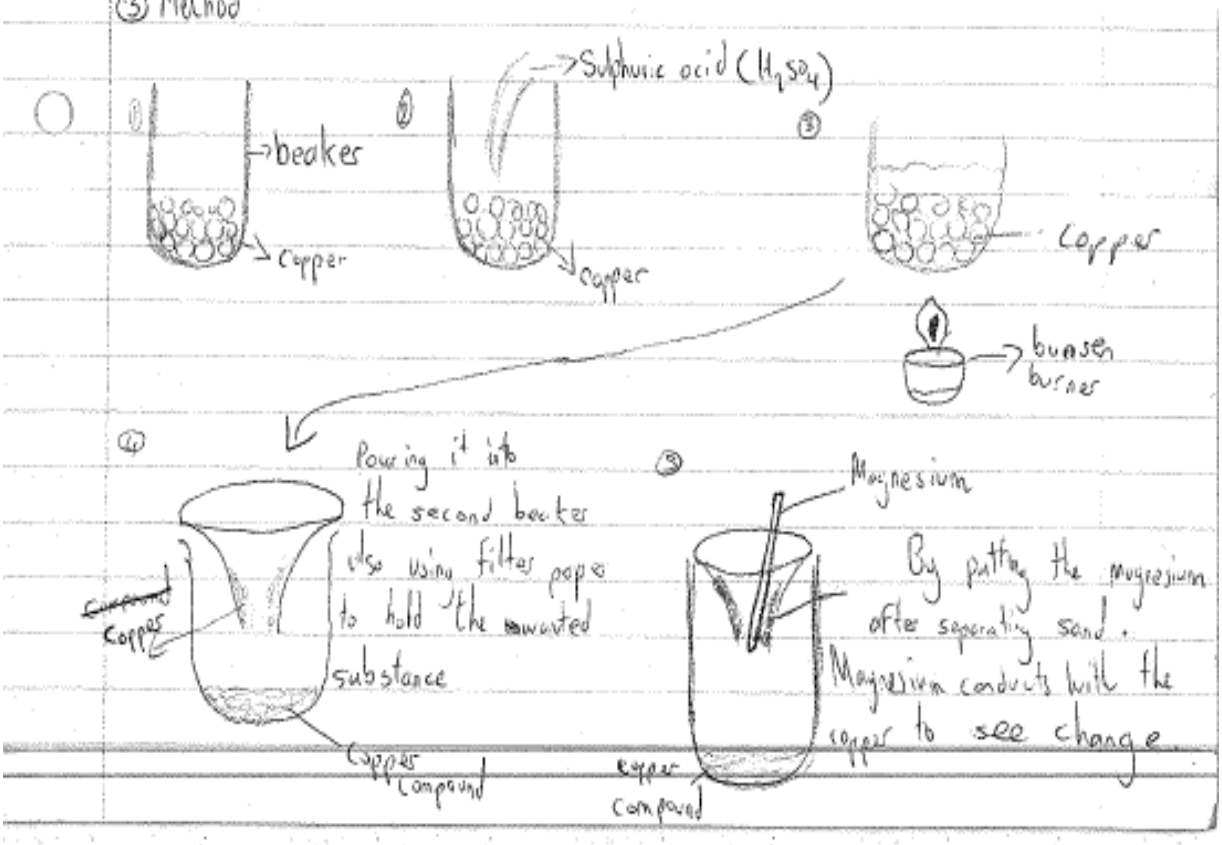
Process of extracting copper.

① Aim

To extract the copper compound mixed with sand

② Bunsen burner
Funnel
Filter paper
Two beakers
Zinc powder
Copper compound mixed with sand
Dilute sulphuric acid

③ Method



1

Practical write up Mixing

Aim of the practical

For us not know how to extract the metal. But to extract copper from ore. using zinc powder

Method

