A CASE STUDY OF TWO EXPERIENCED SCIENCE TEACHERS' USE OF PRACTICAL

BY

KABELO SITOLE

(476826)

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MSc (Sci. Ed).

Supervisor

Dr Mpunki Nakedi

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DECLARATION

I declare that this research report is my own, unaided work. It is being submitted for the degree of Masters in Science Education in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University, nor has it been prepared under the guidance or with the assistance of any other body or organization or person outside the University of the Witwatersrand, Johannesburg.

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K. S. Sitole

____day of _________, 2016

Abstract

This research project was a case study that investigated how two experienced science teachers, who were undertaking self-studies to improve the use of practical work in their classrooms as part of their BSc Hons research projects, actually developed their strategies for effective use of practical work. This study explored the effectiveness of practical work by analysing 6 'typical' science lessons i.e. introduction, practical session and consolidation lessons in two schools around Gauteng in South African. The research design took a form of classroom observations through audio and video recordings and also interview and questionnaires schedules with the two participant teachers. Abraham and Millar (2008) argued that many science teachers do not implement practical work effectively when teaching in their classrooms and most learners fail to relate what they do in practical work to other aspects of their learning.

This research project hoped to find an answer to main research question:

> *How effective are the two participating teachers' strategies of using practical work to promote conceptual and procedural understanding?*

The data analysis used a model of effectiveness on the work done by Millar, Marechal and Tiberghien (1999) and Tiberghien (2000). The two teachers focus in these observed lessons was to promote and develop conceptual and procedural understanding. This study found that practical work in some cases was effective in getting the learners to do what was intended for them to do with objects and materials e.g. apparatus, but the was less evidence of the effectiveness of practical work in getting the learners to use the intended scientific ideas from the data they collected and also little evidence of them showing the understanding of what they were intended to understand e.g. cognitive challenge of linking the observables to ideas.

The study revealed that learners get more procedural understanding and less conceptual understanding in a given practical activity. The study also revealed that teachers faced a lot of challenges when implementing the use of practical work in their classroom e.g. time constraints, minimum availability of resource, less CAPS training etc. and these challenges often hinders the use of practical work as part of the learning and teaching of science. This study further recommended that the department of education do more to support the teachers in their implementations of certain teaching strategies e.g. practical work and that the use of practical work be considered at the fore-front of learning and teaching of science.

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Chapter 1 Overview and Background

Introduction

In the past few years, the South African schooling curriculum has experienced changes which called for a need to put more emphasis on practical work. According to Abraham and Millar (2008) practical work is central to the effectiveness of science education for both teachers and scientists. Several studies have revealed that practical work is not serving its purpose in science classrooms (Hodson, 1990; Bennett, 2003) and that there is a lack of meaningful use of practical work by teachers (Hodson, 1990; Stoffels, 2005; Perkins-Gough, 2007). Abraham and Millar (2008) argued that most learners fail to relate what they do in practical work to other aspects of their learning. This research project is a case study which was aimed at investigating how two experienced science teachers, who were undertaking self-studies to improve their use of practical work as part of their BSc Hons research projects, actually developed strategies for its use in practice.

Context and Background of the Study

In educational research the context at which the research will be conducted is important. This research project was performed in two secondary schools around the Johannesburg district of Gauteng. In the South African context, the use of practical work has had its share of challenges, as endless curriculum changes unfolded since 1994. The curriculum change entailed more inclusive education for learners which resulted in the formulation of the outcome based education (Rogan, 2004). In addition, these curriculum changes have had an impact on the use of practical work in science classrooms. The current situation in South Africa sees practical work as being part of the learning and teaching of science, but it is not formally examinable.

South African schools are currently using the Curriculum and Assessment Policy Statement (CAPS) as part of the schooling curriculum. The CAPS document considers practical work in a form of practical experiments, investigations, demonstrations and projects (Department of Education, 2011). These activities are aimed at developing skills such as problem solving and scientific inquiry, which includes skills such as observation, analysis, drawing conclusions and data collection (DoE, 2011). According to CAPS, practical work has to be “integrated with theory to strengthen the concepts being taught” (DoE, 2011, p11). This suggests that the main emphasis of the CAPS for science is on the use of practical work and need to integrate it with the theory, to ensure better understanding of concepts.

Rogan and Grayson (2003) argued that South Africa is in danger of falling into a trap of designing educationally sound policies, but failing to focus on how these should be effectively implemented. The use of practical work has always been an integral part of engaging learners to concrete learning experiences in science classrooms (Hofstein & Lunetta, 1982). Hodson (1990) traces its use as far back as 1883. In South African schools, despite the goals and objectives outlined in the CAPS document, implementation of practical work has been a challenge for many teachers. According to Ramnarain (2011), South African schools, lack autonomy in their use of practical work resulting in teachers using demonstrations and cookbook approaches which relegates learners’ participation to mere following of teachers’ instructions. This study highlights how the implementation of CAPS is actually problematic for some teachers and schools.

The study by Nakedi, Taylor, Mundalamo, Rollnick and Mokeleche (2012) argues that the change from national curriculum statements (NCS) to CAPS was not only a draw back to the apartheid curriculum, but has also pushed the education system into confusion, because the syllabus was changed without being sign posted. In this study, Nakedi *et al*. (2012) examined the NCS curriculum documents and examination papers to see if there were any congruency between successive documents regarding the weighting and conceptualisation of the LOs. The study revealed that there was a retreat from the original vision of weighting skills (LO1) and relevance (LO3) equally with content (LO2) which resulted in privileging of content oriented science at the expense of inquiry oriented and contextualised science. They further argue that the retreat from these two internationally recognised best practices in the teaching and learning of science has now been cemented by the introduction of CAPS document, a move which has served to subvert the heritage and retard the progress which was already registered within the science education/schooling community.

In South African schools, some science classrooms are lacking the laboratory equipment for performing practical tasks while other schools do have the equipment (Makgato & Mji, 2006). The focus of this study was on how effective the two experienced practicing science teachers use practical work in their classrooms as they undertook self-studies and how they perceived the nature of practical work in their classrooms.

Problem Statement

Although much research has been done on the use, role, purpose and effectiveness of practical work in other countries, little is known about the effectiveness of practical work in the South African schooling context. The study by Mudau (2007) found that there are attempts to conduct practical work in this country and that there is a need to link understanding of practical work and teacher practices. Makgato (2007) on the other hand argues that the lack of appropriate practical experiments in most South African schools results in poor performance in Physical Sciences.

The ideal situation regarding the use of practical work is that it makes science real for learners. Abraham and Saglam (2010) argued that practical work makes physical phenomenon real to learners because it encourages observations, recording, using scientific methods and promoting problem solving skills. In addition, Kipnis and Hofstein (2007) assert that practical work has been recognised as an instructional strategy that is effective in science teaching and learning. At the same time, if used properly by learners it can improve understanding of science. It is argued that effective use of practical work can help learners to develop understanding of science, acquiring of hands-on skills as well as appreciation of science as evidence-based (Abraham & Millar, 2008).

According to Hodson (1990) however, use of practical work in most classrooms is confused, ill-conceived and unproductive. Vhurumuku (2004) on the other hand points to the fact that laboratory strategies used, activities and the nature of interaction in practical work are still far from being understood. In the same breath, the concern raised by Abrahams and Millar (2008) was that for many children the activities and what goes on in the laboratory often contributes little to their learning of science. These studies (Hodson, 1990; Abraham & Millar, 2008) suggest that the use of practical work in many schools is not productive and learners do not benefit from it as intended by their teachers.

The other group of studies (Collete & Chiapetta, 1989; Bennett, 2003) points to teacher expertise in using practical work effectively in their classrooms. The argument by Bennett (2003) is that views of teachers about practical work may or may not reflect their actual practice in classrooms. Moreover the consequence of not using practical work effectively and as intended is that most learners fail to relate what they do in practical work to other aspects of their learning (Abrahams & Millar, 2008). As a result, this research project was aimed at investigating the potential of practical work in promoting conceptual and procedural understanding in science classrooms by tracing the efforts of two experienced science teachers, who undertook self-studies to improve their use of practical work.

Purpose Statement

The purpose of this research was to investigate *how two experienced science teachers, undertaking self-studies to improve use of practical work in their classrooms, actually developed their strategies for its effective use*. This research proposed to give insights on the usefulness and effectiveness of practical work for learners' understanding by linking the content learnt in science classrooms to the practical tasks done. In addition, it aimed to explore how science teachers' views about the use of practical work in their daily teaching routines as well as their views of the nature of practical work, shifted, as they engaged in self-studies.

Research Questions

In considering the research problem, the main question of this study was: *How effective are the two participating teachers' strategies of using practical work to promote conceptual and procedural understanding?* The main question was investigated by seeking answers to the following sub-questions:

1. *What perceptions do the teachers hold about use of practical work in teaching science?*
   - *1.1 What views do they hold about the nature of science?*
   - *1.2 What in the participating teachers' perspectives are some of the factors that hinder the use of practical work in science classrooms?*
   - *1.3 How are the two science teachers relating the content learnt in their science classrooms to the practical work done?*
2. *What strategies do they use to promote conceptual understanding and procedural knowledge in their learners?*
3. *How are their professed aims for doing practical work aligned with what actually transpire during the actual classroom implementation?*

The research questions outlined above were in such an order where they first addressed what teachers' views were regarding aspects of practical work and its use in classrooms. For the sub-question, teachers had to give their perspectives regarding factors that hindered their use of practical work, which were captured through interviews and questionnaires. These factors in a way were going to influence their practice. The second, third and last questions looked at the practical aspects of the teachers' use of practical work, these aspects would be guided or influence by the factors stated in the first research question. This implied that these questions looked at what teachers said or their views versus what they actually did in practice. This also helped me in linking what they said and be able to align that with their actual classroom practices through video and audio observations. These observations gave me first hand proof of what the teachers and their learners did during practical activities.

The first research question looked at the teachers' perspectives of the factors that hindered the use of practical work. In answering this research question, data from both the pre and post interviews and questionnaires (see appendix 6 & 7) were used in answering this question. The teachers in the interviews and questionnaires were asked about the factors that they perceived as hindering their use of practical work. To check for the validity of their view, the teachers were given pre-interviews and pre-questionnaires and their views in these two were compared with their views in the post-interview and post-questionnaires

The second research question looked at their aims and how they align to what they do in practice. This question was answered using the pre- interviews and pre-questionnaires, peer engagement sessions as well as their classroom observation data. Firstly, their aims were capture through the interviews and questionnaire and also through their pre-planning during the peer engagement meeting audio recordings, where they discussed what they will be doing during the practical sessions. There was an alignment in the aims as outlined from the data; secondly the alignment of their aims to their actual practice was retrieved from the classroom observations through audio and video recordings. These were used to see whether what the teachers said in their pre-interviews and questionnaires, peer engagement session aligns with what they do in their respective classrooms. Chapter 4 discusses these alignments in detail.

The third research question looked at the practical aspects of teachers' use of practical work, with the focus on the strategies that teachers used in promoting conceptual and procedural understanding. The data that was used to answer this question was retrieved from the peer engagement session audio recordings, pre and post-interviews and questionnaires as well as the classroom observations. The peer engagement session audio recordings gave me an idea of the teachers plans prior to the observations which included their strategies. The pre and post-interviews and questionnaires also gave me their prior views of how they promote conceptual and procedural understanding. On the other hand, the classroom observations gave first-hand evidence of the strategies that the teachers actually chose to use to try to promote the learners conceptual understanding and procedural knowledge. For the fourth and last question, data was drawn from the classroom observation audio and video recordings as well as the pre-interviews and pre-questionnaire. The interviews and questionnaire, had questions that required the teachers to express their views of how they relate content taught in classrooms and their actual practices. For more details on the questions outlined above and how they were answered refer to chapter 4.

Rationale

A lot of research has been done with the focus on the effectiveness of practical work in developing countries (Abraham & Reiss, 2012; Abraham & Millar, 2008, Millar, 2004), on the other hand effective use of practical work in the South African context within the framework of recent curriculum changes, is still not yet been investigated. There are several studies (Rogan & Grayson, 2003; Rogan, 2004; Mudau, 2007; Singh, 2014) that were conducted based on practical work implementations and use in South African schools but use of practical work in promoting conceptual and procedural understanding has not yet been investigated, a gap in the research field which this present study hoped to contribute to its address.

According to the CAPS document, the teaching of science in the curriculum should include the understanding of how scientific enquiry is performed, the kinds of reasoning that scientists use in linking data and explanations, the types of claims scientists make and the roles that the scientific community take in checking knowledge claims (DoE, 2011). The expectation of CAPS is that learners must be able to conduct experiments, investigations, demonstrations and projects as part of their assessment. These activities are meant to promote scientific enquiries and encourage learners to be aware of their environment and be equipped with skills of investigation (DoE, 2011). This suggests that according to CAPS, practical work in science teaching plays a central role.

Despite what is written in the CAPS document, the implementation regarding the promotion of conceptual and procedural understanding is yet to be seen in the South African schooling context. This research project aimed to provide insights on the potential effective use of practical work in South African schools. The project focused on two experienced practicing science teachers, who undertook self-studies to improve the use of practical work in their classrooms. Furthermore, this project aimed to raise awareness of issues around the potential impact of practical work as a tool in the teaching and learning of science in schools. It was also hoped that the study would provide teachers with alternative strategies on how practical work can be used for effective learning and teaching in science classrooms.

What made me interested in this field of study of practical work was that at school we never performed practical task and even when our teacher tried it did not work out. I always believed that learning through seeing is the best way of learning. When I got the opportunity to do research, immediately I thought of practical work, I wanted to know in depth how it works and how it could be used to help learners and teachers. This particular research project I wanted to explore how teachers teaching the same grades use practical work in their classroom and how I would one day make use of it in my teaching.

Conclusion

This chapter used the relevant literature to discuss the background of the study in terms of the research context, problem statement, purpose statement, and the rationale for doing this study. This chapter was aimed at giving a prelude to what this study was all about. The next chapter will review the literature and culminate with the conceptual framework that informs this study.

Preview of the Chapters that follow giving the structure of the report

In Chapter 2, I reviewed literature related to the questions and therefore the significance of this study. I reviewed literature on the historical use of practical work, its different definitions, purposes and types as conceptualised by different scholars, I then moved on to consider literature on the South African schooling curriculum and how it positions practical work, and then on science teachers' perspectives on practical work, its effectiveness, and then ultimately to the problems associated with its implementation in most schools. The chapter ends by discussing the conceptual framework adopted in this study.

Chapter 3 outlines the research design and methodology that were employed in this study. This study had to adopt a suitable research design to investigate how effective is practical work in some science classrooms. The chapter discussed and justified the actual research design employed in the study, the data collection method and tools, sampling technique, data analysis, issues of rigor, validity and reliability as well as issues of confidentiality and ethics consideration.

Chapter 4 discusses analysis and interpretation of data using the adopted analytic framework and moves on to present the findings of this study.

In Chapter 5, the reflections and conclusion of the study were outlined and a discussion on how the research questions were answered. The limitations, recommendations and suggestions for future studies were also discussed.

CHAPTER 2: Literature Review and Conceptual Framework

Introduction

In this chapter, literature which is significant to this study was reviewed. This includes review of literature on the historical use of practical work and the different definitions of adopted by different scholars, the schooling curriculum and nature of practical work in South Africa, literature on teachers' perspectives about practical work. Further on, literature on the use of practical work in promoting learners' conceptual understanding and procedural knowledge as well as on problems of assessing practical work and the concepts of evidence were all reviewed. This chapter culminates with a discussion of the conceptual and analytical frameworks adopted in this study.

Historical use of Practical Work

Practical work is not a new teaching approach in science classrooms but it has been used in the past. Lock (1988) saw practical work as a waste of time, and this was because teachers did not understand its role as an effective tool for the teaching and learning of science. Practical work is not a new approach to the teaching of science and Gee and Clackson (1992) traces its use as far back as 1850's. Hodson (1990) argued that since 1883 science instruction was expected to be given as experiments by the Education Department in New Zealand, UK and Australia. According to Hofstein and Lunetta (1982) science classroom laboratory have been used for a long time in engaging learners in concrete learning experience.

The use of practical work in science classrooms had its own challenges. For decades until now, teachers have always had a challenge in using practical work effectively, because of not understanding its nature as a teaching and learning tool. According to Hodson (1990), most teachers used practical work unthinkingly because they did not know the main purpose of practical work in the learning and teaching of science. Unfortunately, several studies suggest that this problem still persist to recent years (Stoffels, 2005; Abrahams & Millar, 2008).

In South African schools, practical work has been used in the past and has had its own share of problems. The study done by Muwanga-Zake (1998) found that most textbooks in South

African schools do not outline the aims of practical exercise or processes of science which the practical work has to develop. Muwanga-Zake (1998) further argued that experiments used in classrooms scarcely relate to learner's real lives and environment or challenge the learners practically and intellectually.

What is Practical Work?

Even though practical work is defined differently by many authors, it is generally seen as an integral part of science teaching and learning. Practical work is viewed by many scholars (Millar, 2004; Rollnick, 2003; Millar *et al*., 1999) as any learning and teaching activity which at some point involves learners observing or manipulating objects and materials. Several authors like (Hodson, 1998; Tsai, 2003) viewed practical work as laboratory based work that comprises of experimentations and that gives learners laboratory-based experience. This suggests that experiments were also recognised as kinds of practical work and that when learners engage in practical work, they gain experience based on what they dealt with in the experiment.

According to Lunetta, Hofstein and Clough (2007) laboratory activities are learning experiences where learners engage with secondary data or materials in observing and understanding their natural world. Stoffels (2005) views practical work as the teaching and learning situations that offer learners an opportunity to engage in an investigation of some kind and argues that it must include hands-on and minds-on learning opportunities to assist learners in developing various process skills. This suggests that practical work should be used to enable learners to use their minds and their hands in developing skills such as observation, questioning, collecting of data, manipulating objects, recording data etc. Stoffels (2005) further.

According to Hofstein and Namman (2007) types of practical work include projects, investigations, inquiries, projects or field trips. The above argument suggests that practical work comes in a variety of forms, but these forms should include learners doing things on their own. Several studies (Kask & Rannikmäe, 2006; Ottander & Grelsson, 2006; White, 1996) argued that inquiry based learning through experimental work develops learner's process skills. Donnelly (1998) argued that practical work includes individuals/small groups doing laboratory work and this does not include teacher demonstrations, suggesting that teacher demonstrations are not considered as practical work because practical work must involve the individual or group of learners doing things on their own and with little guidance.

Pekmez, Johnson and Gott (2005) on the other hand, viewed practical work as the movement that influence it, meaning that practical work can be viewed as discovery learning where learners' thinking is developed. This suggests that if a learner discovers something, he is learning and the discovery is influenced by the movements occurring during his observation in the practical tasks. Various authors in these sections defined practical work differently, some with similar ideas.

The Schooling Curriculum and Nature of Practical Work in South Africa

Since 1994, the South African schooling curriculum has undergone multiple changes towards learner inclusive type of education which gave rise to outcome based education (Rogan, 2004). The change in the curriculum from outcome based education (OBE) to revised national curriculum statements (RNCS) then to national curriculum statements (NCS) and then currently to curriculum and assessment policy statement (CAPS) has had its own share of challenges and has caused confusion amongst many teachers, since these curriculum policies had different goals and outcomes. In the year 1997, the South African government introduced Curriculum 2005 (C2005) in GET and FET phases. C2005 had three distinct features i.e. OBE, learner centeredness and integrated approach to knowledge that presented a shift in the curriculum where teaching could be understood (Chisolm *et al*., 2000). There were a lot of criticisms regarding this curriculum, with Jansen (1999) arguing that it would not succeed because it was driven by political agenda that is lacking of classroom life realities.

CAPS as the current curriculum consider practical work in forms of practical experiments, investigations, demonstrations and projects aimed at developing learners' skills of problem solving and scientific inquiry which include observation, analysis, drawing conclusions and data collection (DoE, 2011). According to CAPS, practical work has to be "integrated with theory to strengthen the concepts being taught" (DoE, 2011, p11). The introduction of the CAPS document meant that there were more regulated learning programs than there has previously been and the workbooks were central, this resulting in less responsibility on teachers interpretation of the curriculum outcomes (Singh, 2014).

The CAPS document supports the use of practical work, part of formal assessment in the document for practical work is broken down into three parts/units i.e. the section of ‘practical activities’ including experiments or projects and practical demonstrations that are used in strengthening concepts, basic ‘experiments’ which refer to outlined instructions that learners can following obtaining results need for verifying theories and finally ‘practical investigation’ which require learners to go through basic scientific processes (DoE, 2011).

According to the CAPS document, the teaching of science in the curriculum should include the understanding of how scientific enquiry is conducted, the kinds of reasoning that scientist use in linking data and explanations, the types of claims scientists make and the roles that the scientific community take in checking knowledge claims (DoE 2011). The expectation is that learners must be able to conduct experiments, investigations, demonstrations and projects as part of their assessment and these activities are meant to equip learners with skills of investigation and encourage them to be aware of their environment (DoE, 2011). In the CAPS document the assessment standards and learning outcomes of the NCS were replaced by themes and topics, were learning areas are called subjects (The Oxford Team, 2012).

Despite the goals and objectives of the CAPS document, its implementation has been a challenge. This suggests that the implementation of the CAPS document was problematic for most teachers.

Furthermore, Ramnarain and Fortus (2013) found that the introduction of the revised curriculum meant that South African physical sciences teacher taught the content which was supposed to be in the examination, skipping other relevant content in the document, due to the overload of content. The implementation of the curriculum was affected by many factors one of which was overload of content. The study by Dlamini (2008) on the exploration of how Natural science and Life science teachers address scientific investigations prescribed by the CAPS policy document in their classrooms showed that most teachers used teacher-centered approaches instead of using open inquiry. The study further showed that there was a gap between the Department expectations and the teaching that goes on in the classroom. These studies show some of the challenges that teachers face in the implementation of the CAPS document and other curriculums and it is worth tracing them back from considerations of how shifts happened from NCS to CAPS.

The NCS curriculum had its own problems, the problem with the implementation of NCS was that most teachers in South African schooling were not able to translate and understand what was in the NCS by unpacking it into practice (Nakedi, 2014). It is important to note that NCS had to accept the same principles as that of C2005. As depicted by Ngema (2011), the main aim of OBE was to use outcomes driven curriculum to ensure shifts from the teacher-centred approaches to learner-centred approaches. In the physical sciences, the curriculum was driven by three learning outcomes and according to DoE (2003) it is argued that these three learning outcomes (Learning outcome 1, 2 & 3) and their assessment standards are equally important. Unfortunately, what is written in the policy documents and the actual teaching practices regarding these outcomes, are totally different. As illustrated in the study by Nakedi, Taylor, Mundalamo, Rollnick & Mokeleche (2012), in 2005 the grades 10-12 exam guideline showed that 30% weight was on LO1, while LO2 had 40% and LO3 had 30%. This suggests that in reality the weighting of these LOs was not equally distributed in physical sciences and favouring LO2 which continued the historical pattern of emphasizing content, at the expense of the other two LOs. Given the nature of LO1, this has implications for the use of practical work in this country. (

Nakedi *et al*. (2012) further argued that the examinations are not suitable in assessing the first and third learning outcomes (LO1 & LO3). In the examination LO1 and LO3 are assessed through two practical investigations and a research project weighting 10% and 5% respectively (Nakedi *et al*., 2012). Furthermore, these research projects were a pen-and-paper exercise (Nakedi *et al*., 2012). This suggests that practical work in South African schools is often theory-based rather than practically-based, meaning what is written in the official documents is not practiced in classrooms.

The main problem was that what the NCS described as the ‘scope’ of LO1 was not implemented in classroom practice, the skills for LO1 according to the NCS are that learners have to develop and use the study of physical sciences similar to those used in science by scientist (Nakedi *et al*., 2012). On contrary, the exam guideline on the other had the Assessment Standard 1 (AS1) suggesting that the learners must solve problems using two or more steps of calculations (Nakedi *et al*., 2012). This suggests that what was written in the NCS and the actual implementation were contradictory and that LO1 was not aligned to AS1 as they should be. Teacher’s role according to LO1 was that they should enable the development of skills by helping learners in carrying out open-ended investigations (Nakedi, 2014). According to Yoon and Kim (2010) one of the crucial disciplines to position learner’s development of skills is through inquiry-based practical work. In order for teachers to understand the role of process and content, they need to understand inquiry-based instruction (Chiapetta & Adams, 2004) as outlined by LO1.

According to Nakedi *et al*., 2012 the change from NCS to CAPS was not only a changed back to the apartheid curriculum but it had pushed the education system into confusion when the syllabus was changed without the changes being sign posted. It is further argued that the NCS had a framework that was built in through a lot of work and expertise, the introduction of CAPS meant this framework was totally lost (Nakedi, 2014). It is argued that the reason for the change in curriculum from NCS to CAPS was to lessen the administrative load that teachers had and ensuring that there was guidance and also consistency for teachers when teaching (DoE, 2011). Furthermore, Singh (2014) argued that the curriculum change from NCS to CAPS was meant to adjust what teachers teach and not how to teach e.g. teaching methods. According to Singh (2014) the manner in which the CAPS document is organised in content format rather than learning outcomes format was prone to the traditional teaching methods rather than OBE methods. These sections have discussed the schooling curriculum and nature of practical work in South Africa; the next sections discuss teachers' perspectives on practical work.

Teacher's Perspectives on Practical Work

These sections discuss teachers' views and perspectives about practical work from several studies. A study by Hatting, Aldous and Rogan (2007) based on the factors that influence the quality of practical work in South African science classrooms, revealed that practical work was conducted in classrooms but little was known about the factors for its implementations. The study further revealed positive attitude and dedication of teachers and their learners in implementing practical work but that there was no evidence of effective practice of practical work in science schools. The study also showed that teachers had challenges in making practical work an effective learning and teaching strategy, the study finding also indicated that the utilisation of practical work is not determined by resources (Hatting *et al*., 2007). For example, a school can have laboratories but not perform practical work and there are other schools that do not have or have poorly resourced laboratories but the teachers are motivated to find ways of doing practical work. Another study conducted by Dlamini (2008) on the exploration of the teaching of scientific investigations in Natural and Life science teachers, the findings showed that most teachers used teacher-centred approaches instead of open inquiry in scientific investigations. The study further showed that there was a gap between the Department expectations and the teaching that goes on in the classroom. This suggests that teachers are aware of practical work, but they do not use it effectively and as expected by the department.

A study by Kim and Chin (2011) on the views that pre-service teachers had regarding practical work's inquiry orientation in the classroom found that the teachers' understanding was narrow when it came to inquiry and practical work. The study further argued that the process of inquiry does not seem be done enough in everyday science classroom (Kim & Chin, 2011). The factors that teachers faced in practicing inquiry based teaching were due to lack of teacher knowledge, lack of time, poor facilities, overloaded content and skills and experience (Kim & Chin, 2011). The study finally suggested that teachers' contexts be examined for the development of inquiry-based practical work.

Finally, a study by Pekmez *et al*. (2005) on teachers understanding of the purpose and nature of practical work, found that the teachers regarded practical work as being beneficial in science classroom, but gave different reasons. These sections discussed teachers' views and perspectives on practical work from several studies. The section that follows considers issues related to use of practical work in promotion of conceptual understanding.

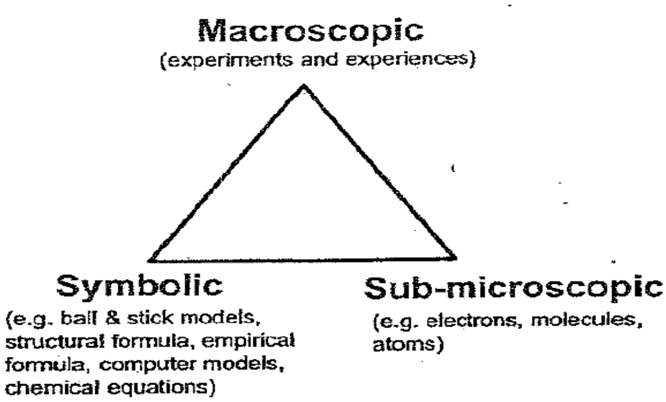
Conceptual Understanding in Practical Work

Johnstone (1982) argued that Chemists refer to chemical phenomenon at three levels of representation which are sub-microscopic, macroscopic and symbolic level of representation and that these are directly related to each other. The sub-*microscopic* level of representation refers to the descriptions of how properties and behaviors of the sub- atomic particles, atoms and molecules affect the bulk properties. The *macroscopic* level of representation deals with observable chemical phenomena; these refer to the bulk properties of phenomena as experienced in daily occurrences i.e. change in colour of a substance. And finally the symbolic level of representation, this level is the scientist's short hand or coding and is used to communicate the link between the microscopic and macroscopic levels of representations. Examples of symbolic representations include algebraic, pictorial, physical and computational forms such a chemical symbols, formulae and equations, graphs, reaction mechanisms, analogies and model kits.

The three levels of Representation

In the learning and teaching of chemistry, learners are often moved through the three different levels of representations i.e. microscopic, sub-microscopic and symbolic.

Figure 1: Three levels of representation



1. Three levels of representation used in chemistry.

The diagram below (**figure 1**) above retrieved from Treagust *et al*. (2003) was used by the participant teachers in moving the learners through the three levels of representations. Treagust *et al*. (2003) argues that most chemists refer to phenomena in chemistry at three different levels of representation i.e. macroscopic, symbolic and sub-microscopic, suggesting that chemistry is easily represented through these three levels of representation.

In dealing with the topics that the participant teachers were teaching, they had to try and move the learners through these levels. The macroscopic level is the observable chemical phenomena in learner's everyday lives (Treagust *et al*., 2003). The microscopic level of representation; this level dealt with the movement of particles such as electron, molecules and atoms (Treagust *et al*., 2003). In this level learners often deal with things that they do not see. Finally, the symbolic representation is argued to construct mental image, and these may include equations (Treagust *et al*., 2003). This level is what learners can relate with the macroscopic level e.g. chemical equation, graph, algebra behind a concept, model kits etc. for better understanding.

It is argued that most teachers assume that learners can easily transfer from one level to another (Johnstone, 1982). When doing practical work, learners are faced with phenomena at these three levels and normally require mediation to make links for clear understanding. In engaging with practical task, learners must be able to link abstract concepts with what they see in reality in order for them to fully understand certain scientific phenomenon. Practical work if done accordingly becomes effective. According to Collete and Chiapetta (1989) the effectiveness of practical work depends highly upon teacher's philosophy. This suggests that if teachers have limited knowledge and do not understand the nature of practical work, their use of practical work will not be effective. On the other hand, if teachers understand the nature of practical work and use it appropriately as part of their teaching, they can use it effectively to assist learners to make links between the content they learn in their theory lessons to the practical task done in laboratory sessions.

Several studies (Abraham and Millar, 2008; Psillos and Niedderer, 2002) argue for use of practical work in promoting understanding of scientific concepts and also enable the learners to engage with ideas built behind the phenomenon and the practical aspects of experiments. In the next section I consider literature on the use of practical work in promoting procedural knowledge.

Practical Work for Procedural Knowledge

Practical work is viewed as the learning and teaching activity that involves learners at some point interacting or manipulating objects that they are studying (Millar, 2004). The learners get a chance to collect, analyse and make conclusions based on their data. The processes that are mentioned above are underpinned by procedural knowledge which Gott and Duggan (1996) refer to as concepts of evidence. They further argue that concepts of evidence form a knowledge base that is linked to substantive conceptual base which is in the heart of science. This suggests that a teacher should be aware that there is a knowledge linked to open investigations which needs to be taught because it does not come automatically when engaging learners in practical work. In scientific investigations learners are required to plan a course of action, collect necessary data and reach conclusions in one way or another (Garnett, Garnett & Hackling, 1995). The problems of the practical activity are required to be devised by the learners.

Importance of Practical Work

If practical work is used accordingly, the following arguments will show the results and suggest why it is importance in science classrooms. Practical work helps learners to develop their understanding of science, appreciate that science is based on evidence and acquire hands-on skills that are essential if learners are to progress in science (Abraham & Millar, 2008). According to Yoon and Kim (2010) practical work is a useful in that it can be used to situate learners towards scientific inquiry and develop process skills. Practical work is also seen as promoting scientific understanding (Psillos & Niedderer, 2002), the understanding includes learning of concepts, model and the development of scientific inquiry abilities. Millar (2004) argued that the importance of practical work is accepted, but it is crucial that the departments of education and curriculum developers ensure that it supports learning and teaching in order to see its purpose. Hodson (1990) argued that knowing what learners do in laboratory gives an education value to practical work.

The views about the use of practical work in science education are different with opposing stand points resulting in its effectiveness not clearly being discussed in practice. Abraham and Saglam (2010) argued that practical works' aims is to promote simple scientific methods of thinking, while Tamir (1976) argued that practical work along with concepts conceptualization are helpful in developing positive attitudes towards science. Other authors (Woolnough & Allsop, 1985; Kempa, 1986) see practical work as being central and playing a role in science education. Several authors (Abraham & Millar, 2008; Millar *et al*., 1999; Gunstone & Champagne, 1990) see practical work as being an essential part for learning and teaching physics and also promoting conceptual change. Practical work is also seen by Psillos & Niedderer (2002) as influencing epistemological understanding. The following sections discuss some of the problems with practical work; these problems can result from teachers not using practical work correctly.

Problems with Practical Work

There are several factors leveled at why practical work is a challenge in most schools with the main reason being lack of resources. Hofstein and Lunetta (1980) stated that poor laboratory facilities become barriers to individual laboratory work and teachers resorted to teacher demonstration. Other studies point to factors beyond resources arguing that if practical work is not used effectively, it can result in various problems during its implementation. Many studies (Millar & Abrahams, 2008; Hart, Mulhall, Berry, Loughran & Gunstone, 2000, Berry & Mulhall, 1999) reported that for most children the activities and what goes on in the laboratory often contributes little to their learning of science resulting in their lack of understanding of the purpose of practical task. This suggests that the use of practical work in many schools is not productive and learners do not usually benefit from it as intended. Pointing to issues in the use of practical work in teaching, Gott & Duggan (1996) argued that the role of practical work is being ill-defined in science education. Cheung (1992) argued that the spread of the use of practical and laboratory work in science teaching may not necessarily be related to achievements in science. In another study Woolnough & Allsop (1985) assert that in most cases, practical activities used in teaching have nothing to do with what practicing scientists do. As early as the 1990s, Hodson had pointed out that most teachers use practical work unthinkingly and that their approach was more hands-on rather than minds-on. In his study of Zimbabwean teachers, Vhurumuku (2004) contended that, for most teachers and learners, there is still a long way in understanding the laboratory strategies used, activities and the nature of interactions in practical work.

Some studies argue that teachers are often the reason why practical work has problems and in her study, Bennett (2003) argued that teacher's views about practical work may or may not reflect their actual classroom practices. Perkins-Gough (2007) points out those teachers in most cases give emphasis to procedures when doing practical tasks instead of the outcomes of the task. In another study, Ottander and Grelsson (2006) found that teachers stress the importance of practical work in their classrooms, but their objectives were not enhancing scientific inquiry since they did not regards inquiry as important. Furthermore, Hodson (1990) contended that a number of teachers think that mere use of practical work results in the acquisition of skills and that this was not the case.

In another study, Tan (2008) argued that laboratory tasks are designed such that learners follow the procedure step by step, rather than making their own meanings and decisions. Abrahams & Millar (2008) caution that further problems regarding practical work may arise due to learners not understanding the instructions and procedures in situation where apparatus are inadequate, resulting in not being able do what the teacher intended. This can result in learners getting wrong results and missing the point of the whole practical session. In the same study, they also point to the teacher's lack of content knowledge and learners' attitudes toward science as possible barriers to effective use of practical work. Hodson (ibid) further argued that unlike the common perceptions, learners' interests are not increased by practical work. Abrahams & Millar (2008) further argue that most learners fail to relate what they do in practical work to other aspects of their learning.

Assessment and Evidence in practical work

The use of practical work has its own problems, purposes and importance, this section looks at another important aspect of practical work i.e. assessment and evidence. These two aspects will help shed light on what are some of the issues related to how teachers assess their learners as they engage in practical activities and how learners would go about producing evidence after completing a particular practical task. This is important since at any point in time, different things can be observed in a given practical task depending on the focus e.g. process skills, practical abilities and communicative abilities.

The experimental stages like formulating problems, designing and planning procedure, setting up the experiment, conducting measurements and observations as well as interpretation and evaluation of experimental data in science can be assessed through tests and examinations (Kempa, 1986), these stages relate to the procedural aspect of practical work. In a practical task, teachers can assess learners' practical abilities and skills in a given task; these skills are crucial for any investigative process and enable first-hand experience of some scientific phenomenon of a particular relationship (Kempa, 1986). In a typical classroom, a learner can be assessed on what they have observed provided that they explain the 'science' behind their observation and with regards to this, Kempa (1986) argued that assessment in the cognitive domain occurs when learners explain their observations and phenomenon in terms of scientific laws, models and theories. This suggests that teacher can therefore identify whether the learners' observations are in line with the intended content or not by focusing on the quality of their explanations.

Kempa (1986) argued that an integral part of science education is in setting of educational goals associated with practical skills and abilities. Furthermore, Gott & Duggan (2002) contends that teachers need to be considerate when assessing learners in practical tasks, because learners' performances may vary due to different factors i.e. context, procedural complexity etc. To deal with these complexities associated with assessment of practical work, Kempa (1986) suggests that teachers should use check lists that are detailed and specific to the performance criteria when assessing learners' practical skills.

According to Gott and Duggan (2002) understanding science requires an understanding of evidence and therefore in assessing the learners, teachers need to consider what evidence the learners present after a given practical task. It is argued that practical work as a learning and teaching strategy can be used to teach about ideas of evidence and has a key role in this provided that the purpose of the practical task is clear (Gott & Duggan, 1996). Gott and Duggan (1996) argue that developing experimental skills in practical work can be approached best by recognising that it is underpinned by a unique knowledge base which is different from substantive knowledge and is linked to understanding of scientific evidence. They further contend that at the time, this knowledge base of concepts of evidence had been excluded in most science curriculums, leading to a hole that causes science teachers' confusion around the role and purpose of practical work being left (Gott & Duggan, 1996).

Gott and Duggan (2002) further pointed out that in a practical task, evaluating the validity of evidence needs to take into consideration the design, data manipulation and measurements which are part of that evidence. In their study, Lubben and Millar (1996) contend that learners' overall performance during practical tasks is determined by their understanding of the importance of empirical evidence and its use in drawing conclusions. They further argue that evidence is crucial in that it enables one to understand and appreciate science and its contributions in crucial debates in the society. This suggests the importance of teachers in promoting the need for their learners to provide evidence when they engage in practical activities and during classroom discussions.

It is important for teachers to note that 'good' results that are obtained during practical work do not necessarily indicate good practical skills from learners (Kempa, 1986) because learners can get 'good' results by merely following teacher's instructions. Integration of these critical aspects in assessing practical work can ensure successful and meaningful use of practical work in schools. The following sections discussed the research paradigm underpinning this study.

Research Paradigm and Theoretical Perspective

In this section constructivism as a general learning theory and then its cognitive and social perspectives are discussed as theoretical perspectives that informed this study.

<u>Social Constructivism and Cognitive theory</u>

Practical work is based on the theory of *constructivism*. Learners in engaging with practical work have to make sense of their discourse and experience and use it to construct meaning (Singh, 2014). This research project used the constructivism theory as the research paradigm. According to Brooks and Brooks (1993) constructivism is a theory about knowledge and learning, not a theory about teaching. This theory explains how knowledge is constructed and how learning occurs and therefore has implication for teaching but it is not necessarily a theory about the teaching of science or any other discipline. The constructivist theory views knowledge as being constructed rather than created or discovered in the mind (Andrew, 2012). This theory relates to the study because in this study the teachers and their learners were developing an understanding through use of practical work.

Learning that results in knowledge construction, begins with a problem or scenario and Cooperstein and Kocevar-Weidinger (2004) argue that constructivist learning often starts with a case, a question or a problem. This is therefore in line with use of practical work where learners are given problems in a form of a practical task. In this study, the aim was to trace this knowledge construction in terms of how the teachers used practical work to support this knowledge construction in their classrooms.

According to cognitive theory, learning begins in the mind of an individual and learning is viewed as being provoked by situations and as a non-spontaneous process (Piaget, 1964). This suggests that without any external situation, learning does not take place. The theory includes the interaction between an individual mental components and information processed through these networks which are complex (Grider, 1993). This theory was crucial in the course of the study, in that it helped in analysing the classroom observation that took place.

When learners come into classrooms, they already have conceptions and ideas that are not scientifically correct (Duit, 2003). These pre-conceptions that learners come with into classrooms can lead to the learners having misconceptions, which can hinder the teaching of new concepts by teachers. Learning involves learners changing these initial conceptions, referred to as the notion of conceptual change (Posner, Strike, Hewson & Gertzog, 1982). Hart *et al*. (2000) argued that conceptual change in practical work occurs when learners reconstruct their thinking as they discuss and reflect on what they were observing. This can enable the teacher to change their conceptions through learning and understanding.

The notion of conceptual change is mainly influenced by the learner's prior knowledge/concepts (Duit, 2003). It becomes hard for some learners to change their existing conceptions about a particular topic, because learners tend to believe that their pre-concepts are always true. Therefore, teachers need to find ways and strategies that will enable the learners to easily change their conceptions, by making science to come 'alive' and demonstrating what they are teaching about instead of being abstract all the time. Also, conceptual change requires that teachers appreciate that these ideas that their learners construct in their minds can often hinder the grasping of new ideas. In this study, cognitive theory was useful in justifying how the learners construct meaning in the classroom and how practical work can be used to facilitate conceptual understanding.

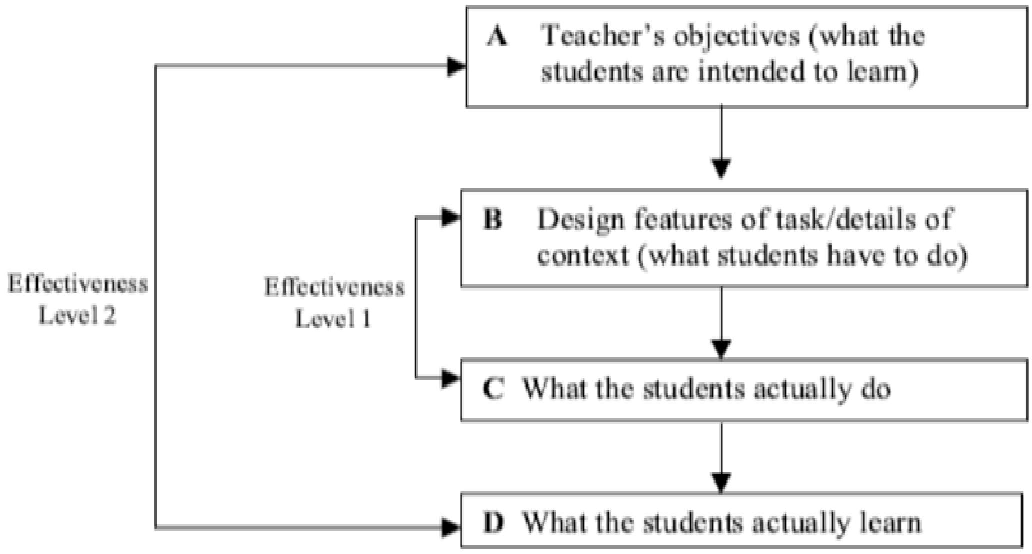
The conceptual framework

As proposed by several studies (Hodson, 1998; Abraham & Millar, 2008; Stoffels, 2005) practical work has been defined differently, with different purposes and aims. With that being said, it would not make sense to look at the effectiveness of practical work as a whole, rather, one has to consider specific task of practical work to determine its effectiveness. This research project employed the model of the process of design and evaluation of practical task proposed by Millar *et al*. (1999) as the conceptual framework **Figure 2**. This model considers the effectiveness of practical task rather than practical work in general.

This model has four stages which are concerned with the design and evaluation of practical task, starting from *Box A: Teachers objectives (what teachers intend learners to do),* this can be a specific aspect of scientific knowledge. Once the specific aspect of knowledge has been decided, the next step *Box B: Design features of task (what learners actually do, what is available for them)*, this might be the practical task that will enable the learners to achieve the objective in Box A and it also considers what apparatus learners are given in order for them to perform the intended task (Abraham & Millar, 2008).

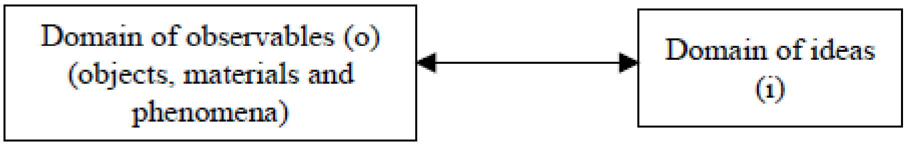
The next stage of the model *Box C: What learners actually do*, this deals with what the learners do as they undertake the task that is given to them. This stage is important in that it will determine what happens in box D (Abraham & Millar, 2008), the learners might not understand the instructions given to them and they might not have the necessary apparatus to perform the intended task, so they might not do what is intended or they might do what is intended (Abraham & Millar, 2008). The final stage (*Box D*) deals*: What learners actually learn*, this stage is concerned with what learners learn after they have undertaken the task given to them (Abraham & Millar, 2008). This model enabled me to analyse the practical task given by the participant teachers. Furthermore, it allowed me to consider and evaluate matches between what the teacher intended learners to do and what the learners actually did, this will result in the effectiveness of the task being at Level 1 (Abraham & Millar, 2008). This model further enabled me to be able to see whether what the teacher intended the learners to learn and whether it actually happened, which therefore would result in the effectiveness of the task being at Level 2 (Abraham & Millar, 2008).

Figure 2



In addition to using this model of the process of design and evaluation of a practical task, I used the domains of knowledge as proposed by Tiberghien (2000) i.e. the domain of objects and observables (o) and the domain of ideas (i) **Figure 3**.

Figure 3



In schools, some of the practical task given to learners deal only with` one domain i.e. domain of observables (Abraham & Millar, 2008), while others deal with both the domains. The domain of observables (o) deals with the ability of the learners to observe the phenomena as the teacher has intended, use the objects and materials given to them to undertake the task as intended by their teachers. The domain of ideas (i), deals with whether the learners think about their actions and observations using the ideas that the teachers has intended them to use (Abraham & Millar, 2008). The two levels of effectiveness in figure 1 combined with the model in figure 2 leads to the analytical framework called the *2x2 effectiveness matrix of practical work* as shown in **Table 1**, which was retrieved from the Abraham and Millar (2008) study was used.

Table 1

Intended outcomes	in the domain of observables (Domain o)	in the domain of ideas (Domain i)
at level 1 (what learners do)	Set up the equipment and operate it in such a manner as to undertake what the teacher intended.	Think about the task using the ideas intended by the teacher.
at level 2 (what learners learn)	To set up and operate similar equipment. Discover patterns within their observations/data.	To understand their observations/data by being able to link them, using the ideas intended by the teacher, with the correct scientific theory.

Table 1. A 2x2 effectiveness matrix for practical work

This table combines the two levels of effectiveness from figure 2 and the domains of knowledge, these are used in determining where the teacher and their learners lie in terms of how they engage in practical tasks and how effective is the practical task. Level 1 of effectiveness can either be in domain (o) the domain of observable and/or domain (i) the domain of ideas in terms of what learners do, while level 2 of effectiveness can either be in domain (o) the domain of observable and/or domain (i) the domain of ideas in terms of what learners actually learn (Abraham & Millar, 2008). The model of the process of design and evaluation of practical task proposed by Millar *et al*. (1999) and the 2x2 effectiveness matric for practical work in table 1 were used in the analysis of the raw data. I was able to check at which levels of effectiveness the participating teachers were working. This scheme of analysis also enabled me to analyse the teacher's practical tasks with regards to how the learners engaged with the given tasks and how the teacher mediates the process.

Conclusion

This chapter reviewed literature on practical work and its aspects i.e. definition, historical perspective, the schooling curriculum and nature of practical work in South Africa, teachers' perspectives on practical work, practical work for conceptual understanding, practical work for procedural understanding, effectiveness and the aspects of assessment and evidence in practical work. The chapter further discussed the conceptual and analytical framework that was used in the data analysis process i.e. constructivism and the model for evaluating the effectiveness of practical tasks by Millar *et al*. (1999). The next chapter will discuss the research design and methodology.

Chapter 3: Research Design and Methodology

Introduction

This chapter outlines the research design and methodology employed during the course of the study. In this study a suitable research design had to be adopted to investigate how effective practical work is in some science classrooms. This chapter discussed and justified the actual research design, methods and tools for data collection employed in the study, as well as how data was analyzed as well as issues of rigor, validity and reliability and ethical considerations associated with the study.

Research Design & Methodology

This research project employed a case study approach. Stake (2006) argued that the nature of qualitative studies enabled them to study experiences of real cases operating in real situations. According to Opie (2004), a case study is the research of in depth interactions of single instances in an enclosed system. Cohen, Manion and Morrison (2002) consider a case study as an approach where researchers observe the characteristics of an individual unit, a school, a class, a child or community. Cohen *et al*. (2002) further argues that the purpose of a case study is to use observations to probe deeply and analyse intensively multifarious phenomenon that form part of the life cycle of units in an attempt to establish generalisations about a wider population to which the unit belongs

It is argued that "the focus of a case study is on real situations, with real people in an environment often familiar to the researcher" (Opie, 2004, p74). Hence this study, which was aimed at exploring potential use of practical work in teaching, focused on investigating how two experienced science teachers undertaking self-studies to improve the use of practical work in their classrooms employed a case study approach. The approach of this study is qualitative since human participants were involved i.e. teacher's views regarding their use of practical work needed to be captured. This approach was useful in getting the actual practices of the teachers as they engage in practical tasks with their learners.

Data Collection Instruments and methods

The research design determines the type of instruments employed in a study (Opie, 2004). For this study a qualitative research approach was chosen and was employed. This approach enabled me to observe the practical tasks that the learners were engaging in, observe the availability or lack of resources in laboratories and also get teachers perceptions about the nature of practical work in their classrooms. It is argued that a research design outlines the data collection procedures including the data analysis procedure followed (McMillan & Schumacher, 2006).

Hatch (2002) argued that qualitative researchers collect as much of detailed specifics from research settings as possible and then look for patterns of relationship among the collected specifics. The aim of this study was to collect data based on teachers' use and views about practical work, which resulted in looking for relationships and patterns amongst the collected data. A variety of qualitative research instruments were used in this study i.e. classroom observations through audio and video recordings, practical observation schedule, interviews and questionnaires, these sections discussed the merits of using these instruments.

<u>Classroom Observation</u>

The classroom observations in this study were done through audio and video recordings. This was done to ensure a comparison between the teachers' views and their actual classroom practices while working with their learners. Observations imply that the researcher had to go to the study site i.e. schools, a classroom, a community meeting space, a staff room and observe what is going on at that site (Bertram & Christiansen, 2014). I therefore went to the teacher's classrooms to observe how they implemented and used practical work in their respective classrooms. The advantage of using observation is that the researcher obtains first-hand data (Bertram & Christiansen, 2014). This influenced my choice of this type of tool, since I wanted to get first hand data of the potential of use of practical work in some of typical South African classroom settings.

According to Creswell (2012), observation is a process where open-ended first-hand information is gathered by observing places and people at the research site. This suggests that when you observe a scenario, you get first-hand information from your sources of information.

Classroom observations were used in an attempt to capture the practices of both the teachers and their learners. In this research project I assumed a non-participant observer role and as explained by Creswell (2012), a non-participant does not get involved in the activities that are happening in the research site. This role allows the observer access to the research site from a vantage point of being able to observe without interfering with the activities taking place as the teacher's implemented practical work in their teaching (Creswell, 2012).

The advantage of using observation is that it uncovers factors previously unknown to the researcher that are crucial for the design of the project, data collection and interpretation of data (Opie, 2004). It was useful in my study in that I was able to uncover practices about the use of practical work as done by the participant teachers. Furthermore, what needs to be understood is that observations are memory based and subjective (Opie, 2004), and this would naturally lead to the subjective procedures in collecting data driven by the researchers' expectations, rather than going with the flow during classroom interactions. In this study, this potential bias in data collection was mitigated by use of audio and video recording of the classroom sessions. Moreover, observations are that information about physical environment and human behavior that can be observed directly by the researcher, the data collecting process can be a useful check on or supplement to that of other means (Opie, 2004).

Despite the advantages of using observation, observations have a number of disadvantages, firstly it is time consuming (Opie, 2004); it takes a long time to observe since the observer must record all the classroom practices of the participants. The limitation of using observations relates to people or participants, during observation whether consciously or unconsciously participants may change the way they behave when being observed (Opie, 2004). Another disadvantage is that observations are influenced by the observer's 'interpretations', they can be bias (Opie, 2004), this could have affected my study in that I could have interpreted my data based on what I expected to happen, rather than what was happening. However, in this study, this concern is mitigated by use of multiple data collection such as teacher interviews and analysis of their teaching artifacts.

Practical Observation schedule

This study employed an observation schedule, which was designed to observe the laboratory practices that were employed by the teachers. The observation schedule employed in this study was from a study by Singh (2014), the schedules are field tested since they were used to collect data in this study and therefore reliable. The Singh (2014) study focused on the factors that affected the use of practical work in some South African schools, this is the reason I chose to use this particular schedule, since it related to my study. The schedule (see appendix 5) focused on the specific events that occurred during the practical session. The focus of the observation schedule was guided by the following:

- Laboratory state
- Resources availability
- Teacher's role
- Teacher's instructions
- Practical activity
- Learners and teacher interactions

The observation schedule also comprised of spaces where one can record the observations at specific times. These observations were an integral part of the capturing of the field notes that helped me in developing accurate instances of particular episodes (Olugbemiro & Taylor, 1995).

<u>Interviews</u>

An Interview schedule was employed in this study. According to Creswell (2012) an interview is a survey form where the researcher records answers which are supplied by participants in research studies. The interview schedule questions were sourced from schedule in previous studies that are related to this one (Pekmez *et al*., 2005; Kang & Wallace, 2005) and also used in the recent study by Singh (2014). The questions were modified to fit this particular study. The interview schedule (see appendix 6) used in this study are field tested and I chose it because it focused on the effectiveness of practical work in other countries.

According to Opie (2004), an interview with respondents, encourages them to develop their own ideas, insights, expectations, feelings or attitudes and this allows them to say what they think. Opie (2004) further argued that interviews offer opportunity of the interviewer to ask a question like why. This also influenced my choice of using interviews. The participants in the study gave their views about the use of practical work and also gave reasons which justified their responses. This research project used a semi-structured interview because it offered me as the researcher, a way of deviating from wording of questions and pre-arranged text (Opie, 2004). According to Fraenkel and Wallen (1990), semi-structured interview provides an opportunity for the researcher to probe in order to clarify answers and also to encourage elaboration in responses. I chose this type of interview because my aim was to get in-depth views of the use of practical work by the participant teachers. Semi-structured interviews were used firstly, to get teachers' perceptions of the purpose and aim of practical work as well as their views about the use of practical work in laboratories and secondly to contrast these with their actual practice.

The interviews were also used in this study because this research project required raw opinions of the respondents, who in this case are experienced science teachers. The interviews provided insights into what the teacher know and believe about practical work and their effectiveness in using it in their practice. They also served to corroborate the findings from other sources of data used in this study. The disadvantage of using interviews is that they require a large amount of time (Akbayrak, 2000). In my case I managed to spend less time on the interviews, since I only had two participating teachers.

Questionnaires

This study employed questionnaires because it required information on teachers' views about their potential use of practical work in order to decide whether it is an effective tool in science classroom or not. The teachers were given pre-questionnaires at the beginning and later in the study completed post questionnaires.

It is further argued that questionnaires are well established research tools within the social science research for purposes of acquiring participants' present and past behavior, characteristics, their beliefs and attitudes on the topic to be investigated (Bird, 2009). This tool was useful in this study in that as a researcher was able to get teachers' beliefs and attitudes towards the use of practical work and their behaviors towards practical work as both a teaching and learning tool in science education. Several studies (McMillan and Schumacher, 2006; Opie, 2004) argue that when using a questionnaire, the element of anonymity is ensured than any other techniques for collecting data. This suggests that the teachers in this study did not have to worry about answering the questionnaires since their names were not exposed due to the anonymity policy. This was also another reason why I chose this instrument because it gave the participants a platform to answer honestly and freely.

The questionnaire schedule (see appendix 7) used in this study was an already field tested tool as it was sourced from Abraham's (1982) study. This study was originally on providing descriptive information about curriculum materials and instructional methods used in science laboratories (Abraham, 1982) and the questionnaire was called the Teacher Perceptions of Instruction (TPI) Questionnaire. The original questionnaire was aimed at investigating aspects such as guided inquiry, open inquiry and investigate verification. In this study there were a number of changes to the instrument, these changes were meant to suit this current study. The questionnaire (see appendix 8) used in this study had two sections and was modified from a Teacher perception of Instruction (TPI) structure by Abraham's (1982).

The original questionnaire made use of 25 statements that described what happens in laboratories during experimentations and it made use of a Likert scale to show how much the respondent agreed with the statements. While for this particular study, the statements were more than 25 and the Likert scale was not used, the statements had to be answered using written answers. This was done because I was interested in teacher's views and how they express them in writing. The questionnaires provided me with teachers' views, where they had time to answer a series of questions related to practical work as used in their classrooms.

Sampling Method

In this study I worked with two experienced practicing science teachers who undertook self-studies as part of their BSc (Hons) qualification to improve the use of practical work in their classrooms. The first teacher, referred to as Mr R for ethical purposes, is a physical sciences and mathematics teacher. Mr R had 19 years' experience and taught at a High School in the West of Johannesburg. Although, learners in this school were mostly blacks from townships and informal settlement nearby, this was historically a white school. Both teachers were currently doing their BSc (Hons) qualification in science education and Mr R held a Bachelor of Education degree.

The second teacher, referred to as Mr K, was a physical sciences and natural sciences teacher with 8 years teaching experience. At the time of the study, he was teaching at a school in Soweto. This township school also attracted mostly black learners from Soweto and other informal settlements near the school. The learners in the school mostly spoke IsiZulu and Sesotho as their home languages, the school offered English as the language of instruction.

Rogan and Grayson (2003) argued that teacher's backgrounds, their training, level of confidence and their qualifications can influence implementation of new ideas. This suggests that if the teachers are confident in what they do, if they have a positive background to their schooling days and they are qualified, they might teach their learners in an effective way by implementing new ideas and innovations and be able to use alternative strategies in their classroom for learners' understanding. With regards to the consent, the teachers were given consent to be involved in the study and they agreed to be part of this study. The consent also made it clear to them that they could withdraw from the study at any time. During the course of the study we met two times a month to discuss some of the concerns that the teachers had if they had any regarding the research process. This made it possible for the participating teachers to withdraw their participation at any given time.

Analysis of data

Qualitative approach involves systematic organisation, collection and interpretation of written materials in a form of text derived from observations or talks (Malterud, 2001). This means that when using a qualitative research approach, getting a deeper understanding of nature of a phenomenon will be the resulting product. The study employed this approach, since teacher's views, their actual practices and the methods they employed during practical tasks and their teaching were part of the things to be investigated.

This section discusses the labelling system that was employed in the discussions. The system was done to organise, sort and guide the result discussion sections. It also helped in summarising and synthesizing the data sets. The labels further assisted in linking chunks of data that were representative of the same phenomenon. Table 3 below shows labels and their meaning as employed in this analysis section:

Table 2: Table showing labels with meanings to be used in the data analysis

Labels	**Meanings**
Mr K	Mr K (Participant Teacher 1)
Task_Intro	Introduction of the task
Task_Prac	Practical Task
Mr R	Mr R (Participant Teacher 2)
(L_S)	Learners

Less_Prep	Lesson Preparations
(L_A)	Learner A
Colla_Meet	Collaborative Meeting
(L_B)	Learner B
(Inter_Trans)	Transcription of Interview Schedule
(Que_Sch)	Questionnaire Schedule

The table above shows the labels that were employed in the data analysis and their meanings. The label (Task_Intro) represents the time the teacher introduced the lesson to the learners. The label (Task_Prac) represents the practical task that the teacher gave to the learners. The label (Less_Prep) represents the lesson preparations that the teacher prepared prior to their teaching of respective lessons.

The (Cons_Less) label represents the consolidation lessons that were conducted after the practical task to consolidate what the learners have leant. The label (Colla_Meet) represents the meeting that me, our supervisor and the teachers had as a platform were the teachers can come and present their ideas. The labels (Mr K) and (Mr R), these represent the first and second participant teachers for ethics purposes. While the learners in their respective classrooms will be referred to by the labels (L_A), (L_B), (L_C) etc. to indicate leaners A, B, C depending on the number of learners in each classroom. Furthermore, the label (L_S) indicates learners; this label will be useful in instances where the learners chorus their answers or talk at the same time. The label (Intro_Trans) represents that transcriptions of the interview schedule and finally the label (Que_Sch) represents the questionnaire schedules that were used in this study.

<u>Ethics Consideration</u>

Ethics clearances for this research project were sought out through the Wits School of education ethics committee. This required me to get consent from the two participating schools which included first the Gauteng Department of Education (GDE) which was an independent application for, as well as the two school principals, the two teachers, their learners and their parents to accept my invitation to participate in the study and agree with all the ethics standards I proposed to adhere to. The GDE application form allowed me to collect data in schools that I have chosen, since the schools are government schools. The ethics application form also included consent letters that explained my research project and what I intended to do in collecting the data. The letters of consent (see appendices 1 & 2) were for the participating teacher, learners, the principle, SGB and learners' parents for them to decide whether they wanted to participant in this study or not. Ethics clearance was granted by the Wits school of education and the protocol number is 2015ECE019M.

It is argued by Opie (2004) that research intended only for the researcher to be awarded a kind of qualification it then considered unethical to be done for that study. In the ethics application what I did was to make it clear that despite the fact that the research will help me obtain my qualification, I also shared the findings with the teachers and the schools so that they can also benefit from the research.

Anonymity and Confidentiality

According to Opie (2004) the social power of respondents could hinder their accessibility. This was my fear because the respondents I aimed to involve in my study might have or not agreed to be part of my study. However, the participants of this study were willing to participate in my study, since they were also co-researchers who were focusing on their own studies whilst they implement the use of practical work in their respective classrooms. This further gave me an opportunity to serve as a sounding board and assist them with their own studies, since I have a background of doing a self-study while I was doing my honours project.

The data collected during the course of this study was kept safe in the university workplace i.e. in my supervisor's offices. When the study was completed, the data will be kept in the university for a number of years, before it can be destroyed. The only people that were present in the room during the interview were the participating teachers and myself only. Furthermore, if there were identifiable features on work, their names were deleted before use. Verbatim quotes used in the research report, were reported so that the learners and participating teachers' identity were anonymous and any specific individuals or courses they may refer to were given pseudonyms. The results of the study were published in such a way that the identity of the participants remains anonymous.

Rigor and Validity

For a research project; the report should be valid and reliable for it to be trusted by the readers. According to Scaife (2004) validity is the ability of a tool to measure what is supposed to be measured. Samaras (2002) argued that there is a need to collaborate with colleagues who can provide alternative interpretations for validity reasons. With that being said, the videos that were recorded during the data collection process were given to two colleagues and my supervisor in seeking alternative ways of representing the data for reliability and validity purposes.

According to Opie (2004), reliability indicate the ‘goodness’ and quality in a research while Wellington (2000) sees reliability as an indication of the extent to which a method, test or tools give results that are consistent across a range of setting and used by a range of researchers. The interview and questionnaire schedules used in this study are reliable because they had been field tested as well as used extensively in other studies (Singh, 2014). Paton (2004) argued that triangulation is a strategy to assess the true value of a study. In this study triangulation was achieved through the use of interviews, classroom observations through audio and video recording and pre- and post-questionnaires. Findings from these instruments were compared and contrasted to find patterns and relationships as argued by Cohen *et al*. (2007). I used more than one approach to investigate my research questions; therefore, triangulation was useful in enhancing my findings.

Guba and Lincoln (2005) argued that credibility is achieved if the participants interpret and understand the findings of the study the same way as the researcher. In this study credibility was enhanced by returning interview transcriptions to participating teachers for verification. Furthermore, the research data and findings were discussed with the participating teachers and my supervisor to resolve discrepant - interpretations.

According to Guba and Lincoln (2005) transferability is the extent to which findings of one study can be applied to other situations. For this study the findings were specific to the two participating science teachers and were therefore not generalizable to a larger population. In order to deal with this transferability aspect, what I did was give my research design and methodology in detail to enable the study to be repeated by other researchers.

The classroom observations were audio and video recorded and verbatim quotes were used in reporting to enhance validity of the study. It is argued that the transcripts of the audio recording can be used to check against bias and misinterpretation (Opie, 2004). To enhance trustworthiness of my findings, the claims made from the observation schedules were triangulated by the transcripts of the actual recording to limit biasness and for my data. The interviews were supported by the audio recording; since I recorded and went on to transcribe the recordings.

The participating teachers were undertaking self-studies to improve the use of practical work as part of their BSc (Hons) qualification. Their own data sets were used to corroborate my findings. A collaborative group was also formed with our supervisor, which became a forum for the two participating teachers to present and discuss their teaching plans as well as get inputs for further modifications and improvement of their teaching plans.

Conclusion

This chapter outlined the research design and methodology employed in the study. The chapter discussed the merits of the data collection methods and instruments, sampling methods used as well as issues of validity, rigor and ethical consideration. The next chapter focuses on the analysis of the results and the findings.

CHAPTER 4: Analysis and Discussions of Results

Introduction

The interplay between the observable and ideas is what constitutes science and a crucial role of practical work is to help learners to develop links between ideas and observables (Abraham & Millar, 2008). In this chapter I explore these particular links using the *effective matrix for practical work* (Table 1: *2X2)* as the analytical framework to analyse data from the classroom observations, the lesson preparations of the teachers and the engagement sessions that the teacher were involved in. The analysis started by looking at the effectiveness of tasks at Level 1 (what learners do) and moving on to look at the effectiveness of task at Level 2 (what learners learn), this was done through the profiling of practical task (Millar, 2002)

In order to explore the effectiveness of practical work for achieving its objectives, one has to be clear on the aims and be able to describe the important features of the practical task in a systematic way (Millar, 2002). The following section will focus and discuss the codes that were employed in the data analysis retrieved from the profiling of a labwork task (Millar, 2002). These codes were adopted from the analytical framework (Abraham & Millar, 2008) and the Millar (2002) study.

The profiling of labwork consists of two major categories regarding practical task i.e. A: *the intended learning objectives* and B: *the key elements of the task design* i.e. cognitive structure of the task, practical context and level and nature of learner engagement. The codes to be presented were developed from these two main categories of labwork or practical task. The following tables and sections will briefly identify the codes used and discuss their meaning.

Table 3: Profiling of practical task: Intended learning objectives codes and their meaning:

A: Intended learning objectives	
Code	**Meaning**
(Cont_A1)	Content
(Proc_A2)	Process

These two codes i.e. content and process, they are used to capture teachers objectives regarding the practical task that they design. The content aspect deals with the learning of the scientific knowledge i.e. related content of the practical task and the process aspect deals with the process the scientific enquiry (Millar, 2002). Furthermore, under the content aspect, it focuses on the how the teacher helps the learners identify objects and phenomena in the practical task, learning facts, learning relationships and learning a theory. If teachers help learners to possess one or more of the above mention features then the code was used. The process aspect, it focuses on how the teacher helps the learners: to use the apparatus or laboratory instrument, carry out standard procedures, plan an investigation to address specific question, process data and support conclusions (Millar, 2002).

The second major category of profiling practical task is B: The cognitive structure of the practical task, which is divided into two categories i.e. What learners are intended to do with objects and observable and what the learners are intended to do with ideas. This category focuses on the learners rather than the teacher. The following codes will be discussed under these two categories in the table below:

Table 4.1: Profiling of practical task: cognitive structure of the task codes and their meaning:

B1.1. What learners are intended to do with objects and observable	
Code	**Meaning**
(Use_B1.1)	Use
(Mak_B1.1)	Make
(Obse_B1.1)	Observe

The codes presented above all deal with what learner are intended to do with objects and observable. The category considers whether the learners did what the teacher intended for them to do with objects and materials that were provided. This is what Hackling (1983) would call ‘producing the phenomenon’. The Use code focuses on how learners make use of observation or measuring instrument and the use of laboratory procedures. The Make code focuses on how the learners make use of materials and make an event occur e.g. mixing chemicals. Finally, the Observe code deals with how learners observe the materials and events (Millar, 2002).

Table 4.2: Profiling of practical task: cognitive structure of the task codes and their meaning:

B1.2. What learners are intended to do with ideas	
Code	**Meaning**
(Exp_Rela_B1.2)	Explore relation between objects and physical quantities
(Test_Pred_B1.2)	Test a prediction from a guess, law or theory
(Acco_Obse_B1.2)	Account for observations by proposing a theory

The codes presented above deal with what learners are intended to do with ideas. This category considers instances where learners used their mental actions in thinking about what they were observing and talking about what they were thinking (Abraham & Millar, 2008). The (Exp_Rela_B1.2) of exploring the relation between objects and physical quantities, this deals with how often the learners identify patterns between objects and physical quantities. The second code, test a prediction deals with how the learners are able to predict the results from a theory, observations, and a law of a hypothesis. Thirdly, the account for observations focuses on the proposing a theory, deals with what learners use when observing to propose a theory (Millar, 2002).

The other sub-category of profiling practical task is *the level and nature of learner involvement* e.g. to what extent does the task involve the learners, is the practical task open-ended or close-ended. The following table will explain the codes used under this category:

Table 5: Practical task profile: level and nature of learner involvement codes and meaning:

C1.1.Task design- the nature of learner involvement	
Code	**Meaning**
(Open_Clos_C1.1)	Degree of openness and closeness of the practical task
(Natu_lear_Invo_C1.1)	Nature of learner involvement

The code related to the degree of openness and closeness of the practical task looks at whether the practical task is open-ended or closed-ended, whether the learners are allowed to do the practical task on their own or their teacher is demonstrating, are the procedure given, interpretation of data by leaners and questions to be addressed in the practical task. The second code deals with the nature of learner involvement in the practical task i.e. does the teacher demonstrate and learners observe, does the learner carry the practical task on their own in small groups or is it carried out individually (Millar, 2002).

The last sub-category of the profiling deals with the practical context i.e. its duration, people who interact, sources of information involved, apparatus used, source of data and tools available for processing data. The following table will show and explain the codes under this aspect

Table 6: Profiling of practical task: the practical context

D1.1. The Practical Context	
Code	**Meaning**
(Dur_D1.1)	Duration of task
(Peop_Inter_D1.1)	People with whom the learners interacts
(Info_Sour_D1.1)	Information sources available to the learners
(Typ_Appa_D1.1)	Types of apparatus involved

The code related to the duration of task considers how long the practical lasts, is it hours or couple of days. The code related to the people with whom the learners interact with deals with whether the learners deal with other learners doing the same task or their teacher. The information sources available deals with the sources of information that the learners have at their disposal e.g. textbooks, handbooks. Finally, the code related to the types of apparatus involved deals with what the learner are being equip with in order to do the practical task.

The analysis of the data will be discussed under the following themes i.e. Intended learning objectives, cognitive structure of the task, level and nature of learner engagement and the practical context, taking into consideration the codes under the categories that were explained in the tables above.

Intended Learning Objectives

Content

As stated earlier, the content aspect deals with the learning of the scientific knowledge i.e. it focuses on the how the teacher helps the learners *identify objects* and *phenomena*, *learning facts*, *learning relationships* and *theories* in the practical task. The following sections will focus on the *Content* aspect of the practical tasks from the data:

(Cont_A1)

For the teachers to be knowledgeable on what content they need to cover during a practical task, I feel like their teaching experience need to be taken into consideration. The teachers have experience in their respective fields i.e. Mr R had 19 years' experience and Mr K had 8 years' experience (Que_Sch). Since they are very experienced, it is easy for them to know the relevant content needed in particular tasks. The teachers will also be able to help learners to relate the content and the practical aspect i.e. learning relationships.

The following was a response from the questionnaire schedule, Mr R in responding to the importance of observations said that it is important for making links between content and theory and those observations are crucial in that learners get '*to use their five senses to form scientific concepts*' (Que_Sch). This also suggests that the teacher will know and understand the relevant aspect of what he needs to achieve during the practical tasks and the aspect of *identifying learning facts*, since the teacher can enable his learners to use their senses during the practical tasks.

The following extracts indicate Mr K giving the learners instructions of the practical task that learners were required to do. This follows from the introduction lesson that the teacher presented to make learners understand the concept better and one learner asked a clarifying question and Mr K answered:

> *Mr K: More heat, more temperature. I see that concept is tricky, you will understand that when you do the experiment, as i said that we will do experiments on this then, we are going to unfortunately the ones that we are going to do involve temperature changes and you are going to see dropping in temperature and rising in temperatures and its actually going to make sense. When you do the practical right, you are going to see how an endothermic reaction behaves and how an exothermic reaction actually behaves; in those experiments which will actually carry out, most of the endothermic reaction are actually physical right. Actually even the reaction vessel if it a beaker it feels warmer, if you hold it, it feels warmer, because energy is actually being released and therefore you are going to see a rise in temperature. (Task_Intro)*

In the extracts above, the teacher saw that the learners had difficulties grasping the concept of heat and temperature. What he did was to assure the learners that in the next lesson they will be able to understand the concepts. This extract talks to the aspect of the teacher helping the learners with relationships and theories i.e. how the temperature of a beaker relates to the concepts of exothermic and endothermic reactions.

The teacher actually listed some of the misconceptions that the learners might encounter as they explored this topic in his lesson preparation. In the peer engagement session the teacher planned to explore learners misconceptions, but there were instances where the teacher failed to pick them out. This further implied that the teacher was also aware of possible learner prior conceptions.

Possible Learner Misconceptions related to the topic of energy change in chemical reactions.

(a) Learners might think that heat and temperature are physical quantities that are the same.
(b) Learners think that the state of being *cold* can be 'move' from a cold area to a warm area.
(c) Might think that cold and heat can be exchanged the same time between two or more objects.
(d) They might think objects lose or gain heat energy and not realise that energy cannot be created nor destroyed but can be moved from one object to another.

(Less_Prep)

This snapshot indicates the misconceptions about energy changes in chemical reaction, but the difference between exothermic and endothermic reaction as a misconceptions was not part of the misconception. Knowing the relevant misconceptions of a particular topic, suggests that the teacher would be able to help his learners to identify the phenomenon in a practical task without missing the concept and also learning about some relationships e.g. how the heat of a particular reaction relates to the theory of exothermic and endothermic reactions.

When asked whether developing scientific knowledge require experiment or not, Mr R said not always, he said that '*in some cases just reasoning can generate knowledge, which can later be proved by an experiment*' (Que_Sch). Later he said that no, '*experiment verifies the knowledge that already exist*' (Que_Sch). This is evidence that the teacher was knowledgeable and uncertain regarding scientific knowledge. This will also suggest that the teacher will be able to help the learners to *identify the learning facts*.

When asked whether science is based on experiments, Mr R said that it is not always that science is based on experiments; this is because scientific knowledge according to him can be generated through reasoning, even in the post-questionnaire he still maintained that '*reasoning is the best way of explaining the microscopic part of the reaction'*(Que_Sch). This gave me an idea of the knowledge of the teacher and how he can be able to help the learners to identify relationships between the observable and the theory.

When asked what he thought an experiment was, Mr K said that it is when learners are allowed to manipulate equipment's in order to generate scientific knowledge. Mr R and Mr K views about experiment are different, in that Mr K's explanation involves learners and Mr R's involves the theory to be proven. When asked whether does the development of scientific knowledge require experiments, Mr K said that '*science knowledge is generated through the use of experiment e.g. Newton's law can be verifies experimentally*' (Que_Sch). When asked whether science is based on experiments, Mr K said yes, he pointed out that scientific knowledge is generated through science methods and that that knowledge is based on experimental observation. This implies that the teacher with his knowledge can help the learners in making relations between what they do with apparatus and the knowledge behind the theory.

Process

The process aspect, it focuses on how the teacher *helps* the learners: to *use the apparatus* or *laboratory instrument, carry out standard procedures, plan an investigation* to address specific question, process data and support conclusions (Millar, 2002).

(Proc_A2)

Despite having experience in a field, further training for teachers is required in helping them to explore other teaching method. The CAPS document training is what the teachers are required to attend to helping them to familiarise themselves with what is in the document. Mr R mentioned that He attended CAPS training in 2013 & 14 for grades 8, 9 and 12. Mr K also attended CAPS training three times. When asked whether the CAPS training helped in the implementing of practical tasks, Mr R said he thinks it's an introduction to CAPS and argued that the time is short to cover most of the stuff in the document. Mr R further said '*we learn* *some of the things when we are teaching and then you discover some of the things'* (Inter_Trans).This suggests that the CAPS training according to him help teachers partially, not with all the aspects. This also suggests that the limited knowledge that the teachers get in the document would help them to help their learners in conducting the practical tasks.

The next section will look at Mr K practical lesson, where he gave instructions to his learners regarding the experiment that they were expected to perform:

> *Mr K: I will bring the chemicals that you guys are going to use. So what you are going to do is, you are going to classify the types of reactions that we are going to do, I will provide the chemicals as I have said and also a thermometer, right. So what it means is that the initially, at the beginning you need to measure the initial temperatures, right?*
>
> *L_S: Yes [Chorusing]*
>
> *Mr K: Now, let me just give, let me have one person per group to just come and get the glass beaker, ah hello (handing out gloves to the students and also the glass beakers).* (Task_Prac)

In the extracts above the teacher gave learners the initial procedure of the practical task; this made the task to be closed-ended investigation. It is argued that in a closed-ended investigation all the information is given to the learners and the decisions are made by the teacher (Hackling & Fairbrother, 1996). Mr K told the learners what to do, how to classify the reactions and also the types of chemicals they will be using. The above sections fall under the category of *process*, where the teacher was helping the learners to *carry out standard procedures* and *how to use the apparatus* in the practical session.

The teacher further gave the learners instructions of how to do and report the experiment as illustrated in the following extracts:

> *Mr K: the important thing for you here is to have the results, make sure that you have the results, draw a table of results, have your initial temperature and your final temperature and as I have said, although it's not it's not the purpose of the experiment to balance the chemical equations. …So the next one that you are going to do, you are going to have water reacting with sodium hydrogen carbonate ($NaHCO_3$).* (Task_Prac)

Mr K made it explicit to the learners that this was going to be a closed-ended investigation. The learners were not given an opportunity to devise their own methods and procedures. It is argued that most teachers tend to focus on making sure that learners understood the procedure that they had to follow (Abraham & Millar, 2008). The above sections further illustrates that the teacher was helping the learners in *carrying out the standard procedures* and how they have *to present their data*.

One of the teachers was also conscience of learner's difficulties prior to the lessons, as illustrated in the following extracts:

> *Mr K: In preparing the lesson, I will consider some of the misconceptions that learners have, learners sometimes think that when you open the door, the cold is coming in, rather than saying heat is escaping. And they also do not differentiate between heat and temperature, so I will use strategies of probing and making them understand.* (Colla_Meet)

The extracts above show that the teacher was prepared for some of the challenges that the learners might have to encounter as they engaged in the topic of chemical change. The above extract shows that the teacher was prepared to help the learners with any difficult that they had with regards to the concepts or practical tasks that they might engage in. This falls under the process category of teachers helping their learners in being able *to process data* and how they can interpret their findings.

The following extracts are from the consolidation lesson for Mr R; the lesson was on energy changes. Mr R, at the end of the lesson wanted to link what learners did in the practical task to one of the example that they did in this lesson:

> *Mr R: 120, its 120 KJ per mol, right listen and this is positive. Which means always when delta H is positive, if you find that delta H is positive, it means the reaction is what, endothermic. Sometimes they say delta H is greater than zero. Sometimes they give you an equation and in front of that I equation they say delta H is greater than zero, you must know that the reaction is endothermic that forward reaction is endothermic, then the opposite will be exothermic. For example, if I had a graph like this, this is energy released, this is energy absorbed. But now do you see that the energy released is greater than the energy absorbed, then if it's like that then its exothermic reaction. Exo, so this is the product. Let go to this diagram, can you tell me what is energy of the products, H of the products?*
>
> *L_O: 150.*
>
> *Mr R: its 150, right 150 KJ per mol minus of the reactants, its 300 KJ per mol. So what do you get here?*
>
> *L_P: -150.*
>
> *Mr R: negative 150 KJ per mol, will this reaction be exothermic or endothermic?*
>
> *L_S: Exothermic [Chorusing]* (Cons_Less) PROCESS, OBSERVE AND EXPLORATION

In the extracts above, the teacher wanted to link what the learners did in the practical task to an example in the topic of energy changes. The lesson was based on how learners interpret graphs when given certain values. Surprisingly, the teacher emphasized on the units when naming quantities '*120 KJ per mol and 150 KJ per mol*' instead of 120 and 150, this indicates that the teacher was using units but the learners failed to use them as they discussed their own measurements during the practical task. This shows evidence that the teacher was actually helping the learners to support their conclusions, in this case it was in a form of calculations.

This instruction followed from the lesson that He presented to introduce the concept of chemical change:

> *Mr R: Right so in the next lesson we are going to carry out an experiment whereby we try to determine whether a reaction is exothermic or endothermic, right?*
>
> *L_S: Yes*
>
> *Mr R: Eh, there are some worksheets here that we are going to use (distributing the worksheets)… Can i give you the instruction there, it says that; 'you have learnt that energy is involved in a chemical reaction', right that change of energy is another chemical change… You see in this case there is no method which is given to you, so now you have that paper you go, you form your groups. On Thursday we are doing this practical, you form your groups and try to come up with a method that you are going to use to determine whether the reaction is endothermic or exothermic using these apparatus. Write down your own method, how are you going to determine whether this is endothermic or exothermic using these apparatus, but now you concentrating on pair number 1, 2, 3, 4 and 5, pair number one is HCl and NaOH I'm going to provide that. Now from here you have to form your group, you discuss as a group, ukuthi (that) we are going to do this and this, we are going to draw our table this way and record our results this way and this way. So that when you come you just follow your plan and then you carry out your experiment and then you can interpret it and draw a conclusion from your interpretation.* (Mr R_Task_Intro)

The teacher in these extract gave the learners the instructions of the practical including the worksheets; the worksheet required the learners to formulate their own methods. These extracts show the teachers' objectives; what the teacher wants the learners to learn from the practical task. The teacher also made it explicit that the practical task was an open-ended investigation by saying '*you see in this case there is no method which is given to you*' the teacher indicated that the learner had to device their own method '*try to come up with a method'*. Hackling and Fairbrother (1996) argued that in an open investigation learners given an opportunity to freely choose any method they want to use to address the question of investigation and Mr R engaged his learners in an open-ended task. Furthermore, these extract showed evidence of the category of process, where the teacher is helping the learners to *plan an investigation* and *carry out standard procedures*. He instructed them to create their own method and how they can go about organizing their result section.

The following extracts show the teacher intervening in what the learners were doing and talking about with regards to the experiment:

L_ U: E kenyemetsing (Put it inside water)

L_V: No I tse I drop (it must drop first) [referring to the temperature of the thermometer]. Okay room temperature,waitse ke bokae? (Do you know how much is it?)

Mr R: Okay, what are you measuring there?

L_U: Atmospheric temperature

Mr R: do you need it?

L_U: Yes

Mr R: why?

L_X: Because it's too far

Mr R: What temperature, are you measuring the temperature, are you finding if it's endothermic or exothermic?

L_V: No! Because it was high, if it measure high it was gonna give us,wantlhaloganya (Do you get me)

Mr R: Its initial temperature in a substance?

L_V: Sir, it was high, so we are waiting for it to drop

Mr R: it can't be zero (Task_Prac)

In these extracts, the learners were taking measurements of the reactions that they were using. But as I pointed out earlier, the learners had an issue with units, they failed to refer to correct and relevant units when they discussed their measurements. This can imply that the learners did not understand what was happening during the practical session; they just followed instructions not necessarily thinking about other levels of representations. Mr R then wanted to probe and help the learners' reasoning to see what and why they were doing what they were doing. This implies that the teacher actually prepared to help the learners.

Mr R was involved in many probes during the practical task session, the following extracts show one of the instances where he was trying to help the learners:

Mr R: Eh what are you aiming to do there, how are you going to, I can see that you have picked up this one (thermometer). How are you going to use this?

L_ E: Measure the temperature.

L_D: Sir, to investigate whether the reaction is exothermic or endothermic.

Mr R: Okay, so when do you measure?

L_D: Haobasiceda uku mixer (when we are done mixing), for example masiceda ukumixer hydrochloride acid neh sodium hydroxide (for example when we are done mixing HCl with NaOH) then sizo (we) measurer I temperature.

Mr R: Then what do expect to see?

L_D: If I high, then its exothermic, if I high yini? If it's high its exothermic, if it's high what is it?) (Task_Prac)

In these extracts the teacher wanted to know whether the learners understood what they were doing by saying '*what are you aiming to do there'*, he wanted the learners to give details of how they will approach the task. Furthermore, he wanted to know how the learners would determine whether what they were measuring was an exo- or endothermic reaction and if they struggle for him to be helped e.g. carrying out standard procedure.

Furthermore Mr K's objectives were also visible in his lesson preparation:

Lesson Objectives:

(a) To explain the following terms:

- Chemical change, bond energy, bond length, endothermic reaction and exothermic reaction

(Less_Prep)

The snapshot above shows part of the Mr K's lesson plan. This part indicates that the teacher had planned to explain and make learners understand on the concept of endothermic and exothermic reactions. Since, the teacher is able to prepare for his lesson, this implies that he will be able to help the learner e.g. how to go about dealing with some of the problems that they might encounter in the practical task session e.g. using apparatus, carrying out procedure etc.

Mr K said that to some extend it does help with implementation, he further said '*we won't be able to cover everything in that document; they will focus on important aspects'* (Inter_Trans). Mr K sees value in the CAPS document in terms of implementation. He further said '*we won't be able to cover everything in that document; they will focus on important aspects'* (Inter_Trans). Mr K sees value in the CAPS document in terms of implementation. All the above mention views deal with the aspect of process, the teacher has to be knowledgeable on how to use different teaching methods and how to implement practical activities for them to be able to help the *learners use apparatus, carry out procedures and plan investigations* using the knowledge from the CAPS documents and its training.

The following section is a response from one teacher on what is the importance being knowledgeable about practical work in science classrooms, Mr R pointed out that the '*use of* *apparatus teaches the learners how to use equipment*' (Que_Sch). This is aligned with the definition of practical work as defined by Rollnick (2003), she argued that practical work involves at some point learners handling object they are studying. This falls under the category of process, since the teacher knowing the importance of using apparatus can use this knowledge to instill in his learners by helping them during a practical activity. The teacher might start by showing the learners the apparatus and their names and then go on to show them how they work, prior to the actual practical activity.

Mr K in responding to the importance of observations in practical activities said that it is important in linking the theory to the observations; he later said that '*so that they learn how theory relates to practical*'s (Que_Sch). For the learners to link the theory to the practicals, the teacher needs to help them make these links in an appropriate way, this falls under the process category of *helping learners plan investigations to process data*. In responding to what reasons would make the practical not to go as planned, Mr K said that the '*lack of discipline in the side of the teacher as well as lack of discipline of the learners'* (Que_Sch). Having this knowledge, the teacher can plan his task knowing that the learners might not be disciplined; he can start by ensuring discipline by helping them to know how to behave in a laboratory.

Cognitive Structure of the task

What learners are intended to do with objects and observable

The level 1 of effectiveness in the practical tasks observed considers whether the learners did what the teacher intended for them to do with objects and materials that were provided. This is what Hackling (1983) would call 'producing the phenomenon'.

Use

Under the Use category we focus on how learners *make use of observation* or *measuring instrument* and the *use of laboratory procedures*.

(Use_B1.1)

The following extracts show a group of learners who created their own method, who were unable to find the method in their textbook like other group of learners:

> *L_D: Asenze i method, sizokhonaukubona into esiyenzayo (Let's do the method so that we know what we are doing).*

L_C: [reading the textbook] bathi dissolve about, angazieya. Ah mus okay thinasizothi (we will say) dissolve about 1 of each of the following substances, bese angithi Sisebenzisa (And then we use). Okay le ikhona neh (okay it is here) calcium nayi (here)

L_B: Nasi is calcium chloride here is calcium chloride [pointing at the textbook]

L_D: nayi (here) soyenzangamanzithina (we going to do it with water) neh calcium chloride (and calcium chloride). Okay ke soyenzange calcium chloride (okay we going to do it with calcium chloride), kusho ukuthi (that means) Lenaangkesiyimixer namanzi I out (we will not mix it with water, it's out), angithisimixer neh lo or sisazoyimixernamanzi (we mix it with... or we mix it with water). Sozimixerzi two besesifakanamanzi? (We mix both then add water?) (Task_Prac).

In this extract, the learner made use of the procedures that they got in the textbook that related to the practical at hand. This implies that the learners were able to utilize or use all the materials that were available to them. This relates to the use category, because the learners use laboratory procedures.

The following extracts are from the actual practical task, where the learners were taking their measurements using the apparatus and chemicals and talking about them:

L_ A: Sir? It is calcium chloride into sodium who now?

L_B: Sulphuric acid.

L_A: Yes! Its sulphuric acid, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, measure. 31 so it's […]

L_B: 81, 91 (holding the thermometer into the beaker with $CaCl_2 + H_2SO_4$).

L_ A: Oh.

L_C: Okay you can remove it ke (then).

L_B: (removes the thermometer). (Task_Prac)

The learners in the above extracts were talking about the measurement and result that they got in the practical task, but again their measurements did not have units. This further indicated that most learners were not aware of physical quantities or it was not emphasized by their teacher. They wanted to get both the initial and final temperature of the reaction between calcium chloride and sulphuric acid. The learner by removing the thermometer shows that she understands that readings might change either increase or decrease if is kept in the beaker for a long period of time. The learners in this case were *using* the apparatus such as a thermometer to measure the temperature of the solutions.

Mr R was involved in many probes during the practical task session, the following extracts show one of the instances where he was trying to help the learners:

> *Mr R: Eh what are you aiming to do there, how are you going to, I can see that you have picked up this one (thermometer). How are you going to use this?*
>
> *L_ E: Measure the temperature.*
>
> *L_D: Sir, to investigate whether the reaction is exothermic or endothermic.*
>
> *Mr R: Okay, so when do you measure?*
>
> *L_D: Haobasiceda uku mixer (when we are done mixing), for example masiceda ukumixer hydrochloride acid neh sodium hydroxide (for example when we are done mixing HCl with NaOH) then sizo (we) measurer I temperature.*
>
> *Mr R: Then what do expect to see?*
>
> *L_D: If I high, then its exothermic, if I high yini? If it's high its exothermic, if it's high what is it?)* (Task_Prac).

In these extracts the teacher wanted to know whether the learners understood what they were doing by saying '*what are you aiming to do there'*, he wanted the learners to give details of how they will approach the task. Furthermore, he wanted to know how the learners would determine whether what they were measuring was an exo- or endothermic reaction. In this above extracts the learners were making *use of the apparatus* such as a thermometer to decide whether the reaction was exothermic or endothermic.

Make

The Make category focuses on how the learners make use of materials and make an event occur e.g. mixing chemicals.

(Mak_B1.1)

The following extracts are from Mr K consolidation discussion with his learners. He taught energy changes and wanted to relate the concept to the practical activities that they did in the previous lessons:

> *Mr K: Let's suppose you were doing this experimentally, like what you did there was bond breaking, bond formation. Now if you are using a thermometer to determine the temperature changes, what do you think was going to happen to the temperature here of this reaction? Was there going to be a temperature rise or temperature drop?*
>
> *L_S: Temperature drop.*
>
> *Mr K: a temperature drop, you still now there, this negative. Let's look at this reaction right, if this one is negative, does it mean that we have a net release or net absorption?*

L_S: Release.

Mr K: is this a net release?

L_T: absorption. (Cons_Less)

In the above extracts, the learners showed evidence of being able to recall what they did previously; they were able to know that temperature drop meant net release. This shows recall, whether they understand or not it is difficult to determine at this stage. Mr K also promoted scientific talk in his class by using concepts like bond breakage and bond formation. The teacher also moved the learners through the three levels of representation i.e. micro, macro and symbolic (Treagust *et al*., 2003). By referring to the experiment '*let's suppose you were doing this experimentally'* this represented the macro level and by mentioning bond breakage and formation, this represented the micro level of representation. Johnstone (1982) argued that teachers assume that learners can move easily from one level of representation to another. In this instance the assumption is proven to be true by Mr K, since it was not clear whether all the learners were getting what he was explaining or not. In the extracts the learners were making use of the information from the previous practicals to relate it to the content of the current lesson.

The following extracts further illustrate how the learners went about discussing their observations during the course of the practical task:

L_A: Ya increaser? E temperature ya increaser (Is it increasing, the temperature is increasing) gwala (write) initial temperature and final temperature.

L_H: Now, ke bo kae now? (How much is it now?)

L_A: 10.4 and ya increaser (10, 4 and its increasing), wo a e relaxy ntwena (It's not relaxing). Ya increaser fela (its increasing only). Ya increaser akere pele e ne ele 10, 1 now e se ele 10, 5 (its increasing at first it was 10, 1 now its 10, 5.

L_G: colour change

L_A: ke e colour change wabo (Here is the colour change you see)

L_J: a o gwale, colour change (Write colour change) (Task_Prac)

In the above extracts, the learners were making observations regarding what they were seeing during the course of the practical. They discussed temperature changes without the necessary units; the learners knew that they were required to get the initial and final temperature for them to determine whether the reaction is exothermic or endothermic. They also observed colour changes, this further emphasizes that discussions are important in helping learners to understand what they are doing (Hackling & Fairbrother, 1996).

When asked whether his school is poorly resourced or not, Mr R said that '*it's resourced, but not enough there are some things that are not there. But it's better than other schools'* (Inter_Trans). This suggested to me that the school was resourced and from my observations I could see that the school does have resources such as laboratory and certain chemicals. When asked the same questions about resources Mr K said that its *'quiet difficult for me to say whether well or poorly, but what I can say is that we do have the minimal equipment that would enable us to do the experiments'* (Inter_Trans). This suggested to me that some resources they do have, while others they do not. Since the schools were struggling with apparatus, it was difficult for me to see how most of the learners make use of the apparatus, which was under the category of Make.

Hattingh *et al*. (2007) argued that there is a relationship between practical work and availability of resource. I further believe that resources on their own do not mean that the practical will be successful, as argued by Hattingh *et al*. (2007) that improving the availability of resources will make little difference if it was not accompanied by interventions. This suggests that teacher interventions are important, the way the teacher uses the resources makes a difference in learner understandings

Observe

Finally, the Observe code deals with how learners observe the materials and events (Millar, 2002).

(Obse_B1.1)

The following extract is from the actual practical task, were the learners were doing their measurements using the apparatus and chemicals and talking about them:

(Prac_Trans)

L_P: Yini I initial? (Whats the initial?)

L_T: 18

L_Q: A yi changi (it doesn't change)

L_S: Isikhathi calani (the time, start it)

L_P: [mixing NaOH and HCl]

L_P: Mix [stirring the thermometer into the test tube with the solution of NaOH and HCl

L_U: Eh kuyanuka (Eh, it smells). This thing smells so awful.

L_Q: Ushile Learner P (Did you get burnt learner P)

L_P: Uzosha (you will get burnt)

L_U: Iyashisa (Holding the bottom of the test tube)

The above extract shows the learners making observations related to the practical task, the observations made use of their sense e.g. smell '*Eh, it smells'*, the learners also knew that the test tube was becoming hot that is why, one of them touched the bottom of the test tube. Hackling & Fairbrother (1996) argued that discussions amongst the learners are important in helping them understand what to do. This shows the category of observe were the learners *observing a phenomenon* and report on it.

The following extract is from the practical task, were the learners were still conducting the investigation in groups e.g. taking temperatures of the reactions that they were dealing with, at the same time keeping track of the time:

(Prac_Trans)

L_T: I two minutes ayikapheli? (Isn't two minutes finished already?)

L_S: Ayikapheli (it's not finished), 36 seconds.

L_U: Stop!

L_Q: Entse (take it out), Ikuphi? (Where is the thermometer reading?)

L_S: Iya decreaser (it is decreasing), it's a hundred and ten

L_T: It maybe be a hundred and six, so its exothermic neh?

L_R: yes

L_U: whats the difference guys 106-18

Learner U: 92?

Learner R: 88

In the extract above the learners were taking temperatures using a thermometer at the same time keeping track of the time, to make the experiment a fair-test. Despite the focus being on measurements, L_T showed an understanding of what was intended for the learners to understand. She said '*It maybe be a hundred and six, so its exothermic neh?'* and L_R agreeing with her shows that they understand the concept of exothermic. The learners in this case were *observing the change in temperature* of the reactions that they were dealing with.

In the following extracts, the learners were discussing amongst themselves about the observations that they had made when they reacted two chemicals:

> *L_D: Initial gwala initial (Initial write initial)*
>
> *Mr K: There we go, let's have uhm [pouring NaOH into HCl]*
>
> *L_B: Ya yatshisa sulphuric e (Yah it's hot this sulphuric)*
>
> *L_E: ke 40 vele? (Is it really 40?)*
>
> *L_E: E fetele? (Did it pass?)*
>
> *L_B: Arere 50 (Let's say, 50).*
>
> *L_D: Yetsa 60 something (Make it 60 something)*
>
> *L_C: ware beaker ya tshesa? (Are you saying the beaker is hot?)*
>
> *L_B: Eya (Yes)*
>
> *L_E: Yatshesa nto e? (Is that thing hot?), o gwale everything ere e observing (Write everything we observe)* (Task_Prac)

In the above extracts, the learners were observing the temperature changes when they poured sodium hydroxide into hydrochloric acid. Their thermometer ended at 50 degrees Celsius, so they decided to estimate the final temperature to 60. L_C also used her sense, as she felt the beaker being hot, while L_E wanted the group write all the observations by saying '*write everything we observe*'. In this case the learners were *observing the temperature change* and also the *reactions*. In this practical session learners were able to evaluate their own work which helped in them reflecting of what they did well and not well (Hackling & Fairbrother, 1996), since the teacher did not get too much involved in their discussions. It was going to be useful for the teacher to go to each group and listen to their discussions, this was going to result to him picking up possible misconceptions and guiding the learners who are off track. Units in this discussion also arose, to indicate that the learners do not know the physical quantities in sciences.

The following table shows the results that the learners obtained whilst they were doing the practical task, the table was extracted from the video recording:

Chemicals	Exo/endo	IT	UT	Time	Diff
Hydrochloric acid & sodium hydroxide	Exothermic	18	106	2 min	88
Ammonium nitrate & water	Endothermic	18	-1	2min	17
Sodium hydroxide & sulphuric acid		18		2min	
Calcium chloride and water	Endothermic	18	14	2min	4
Sodium hydroxide & calcium chloride		18		2min	

(Task_Prac)

For the table above, from the observations that they made when doing the practicals, the learners were able to formulate the above table. The learners categorised their results under either exothermic or endothermic reactions depending on whether the temperature increased or decreased. The learners showed that they understood what they were intended to understand since they correctly identified both exothermic and endothermic reactions using temperature changes in the table. The learners were able to identify temperature increase as exothermic and temperature decrease as endothermic, to show that they understood.

Mr K spoke about discipline being a challenge, when asked about challenges of conducting practical tasks, he stated that his learners tend to be too excited that '*perhaps they loss focus of what you are doing'* (Inter_Trans). Overcoming the challenge of apparatus as pointed out earlier, Mr K resorts to demonstration. When it comes to the learners being too excited, Mr K solves this problem by' *reminding the learners on what they are expected to do, because otherwise they will lose focus'* (Inter_Trans). This would consequently make the learners to not use the apparatus correctly and not observe critically because of their loss in focus and excitement.

What learners are intended to do with ideas

This level of effectiveness considers instances where learners used their mental actions in thinking about what they were observing and talking about what they were thinking (Abraham & Millar, 2008).

Exploring relationships between objects and physical quantities

The (Exp_Rela_B1.2) code focuses on the exploring the relation between objects and physical quantities, this deals with how often the learners identify patterns between objects and physical quantities.

(Exp_Rela_B1.2)

The responses in the following sections were adapted from both the pre and post-Questionnaires:

Mr R, when asked how he feels when responding to a questions that he does not know or makes him feel uncomfortable, said that he has developed an attitude towards his learners and also learn things about them, he said '*when they ask me something that I do not know. I usually throw the question to the rest of the class*' (Que_Sch). He also tells them to go find out the answer as a class and have a '*desire to discover things for themselves*' (Que_Sch). This suggests that Mr R ideas about the nature of practical work have some characteristics of discovery movement (Pekmez *et al*., 2005). He further pointed out that he explains to the learners that teachers are human beings who do not know everything, for them to understand when their questions are not answered. Taking into consideration the above view, the teacher when he says the learners *desire to discover things for themselves*, by discovering things on the own the learners will be in a way exploring ideas during a practical session and would consequently identify pattern on their own. I also discovered that they actually were able to make predictions and identify patterns without the help of the teachers.

The following section shows a discussion that learners had during the practical task:

(Prac_Trans)

L_W: Do you realise that we don't have chemicals here

L_V: We will

L_W: Okay, they must be equal, we don't check. We take the thermometer and then whilst we mixing the chemicals together, obviously if its endothermic, whatever happens it will go up. So, we will use the thermometer to mix, whilst we pouring water. So that if the chemicals release heat, we will see through the thermometer. We don't care about the room temperature)

L_U: All I'm saying is that we have to know the room temperature

L_V: Yes

L_W: We know that is 21, so when it decreases. We will know what it is, which was is it endothermic and then when it increases its exo.

This extract shows evidence that the learners were thinking while they were doing the practical task rather than listen to one learner doing all the talking and following her instructions. As argued by Hackling & Fairbrother (1996) that discussions are important amongst learners that they will help learners to understand what to do. Learners wanted to have a common understanding whilst they did the practical task. The learners in the above extract were exploring relationships between the temperature change and the concepts of exothermic and endothermic reactions, which fall under this category.

The following extracts are from the consolidation lesson for Mr R; the lesson was on energy changes. Mr R, at the end of the lesson wanted to link what learners did in the practical task to one of the example that they did in this lesson:

Mr R: 120, its 120 KJ per mol, right listen and this is positive. Which means always when delta H is positive, if you find that delta H is positive, it means the reaction is what, endothermic. Sometimes they say delta H is greater than zero. Sometimes they give you an equation and in front of that I equation they say delta H is greater than zero, you must know that the reaction is endothermic that forward reaction is endothermic, then the opposite will be exothermic. For example, if I had a graph like this, this is energy released, this is energy absorbed. But now do you see that the energy released is greater than the energy absorbed, then if it's like that then its exothermic reaction. Exo, so this is the product. Let go to this diagram, can you tell me what is energy of the products, H of the products?

L_O: 150.

Mr R: its 150, right 150 KJ per mol minus of the reactants, its 300 KJ per mol. So what do you get here?

L_P: -150.

Mr R: negative 150 KJ per mol, will this reaction be exothermic or endothermic?

L_S: Exothermic [Chorusing] (Cons_Less)

In the extracts above, the teacher wanted to link what the learners did in the practical task to an example in the topic of energy changes. The lesson was based on how learners interpret graphs when given certain values. The learners in this lesson were actually exploring the relationship between what they did in the practical activities to the graphs of exothermic and endothermic reaction in the consolidation lesson.

The following extracts are from the consolidation lesson, where Mr K was doing energy changes with the learners similar to that of Mr R:

Mr K: its 1134 KJ per mol. Now after doing this we can now try to look at the reaction, this is the total amount of energy to break the bonds and this is the total amount of energy that way released in bond formation. Now look at these two how do you classify these two, think is this an endothermic or exothermic?

L_S: Exothermic [Chorusing]

Mr K: exothermic right, why?

L_B: more energy is released than absorbed. (Cons_Less)

The L_S in the above extracts were responding to the question that was asked by the teacher. When Mr K asked whether it's exothermic or endothermic, the learners chorused '*exothermic*'. The learners saying *exothermic* was not full proof that they understood, Mr K continued to ask '*why?*' to check whether they understood the concept fully. L_B responded because '*more energy is released than absorbed'* this suggests that the learner understood this part of the concept of exothermic, but the question is did all the learners understand or not. The teacher was linking the graphs of exo-and endothermic reactions, the learner's observations from the practical task session and the concept of exothermic and endothermic reactions, in one lesson to see whether the learners have grasped the concept or not. The learners seemed to have grasped the concept after doing the practical, because they were able to link the graph to the concept.

Test a Prediction

The second code, test a prediction deals with how the learners are able to predict the results from a theory, observations, and a law of a hypothesis.

(Test_Pred_B1.2)

The following extracts show a discussion that learners had during the practical task:

L_W: Do you realise that we don't have chemicals here.

L_V: We will.

L_W: Okay, they must be equal, we don't check. We take the thermometer and then whilst we mixing the chemicals together, obviously if it's endothermic, whatever happens it will go up. We will use the thermometer to mix, whilst we pouring water. So that if the chemicals release heat, we will see through the thermometer. We don't care about the room temperature.

L_U: All I'm saying is that we have to know the room temperature.

L_V: Yes.

L_W: We know that is 21, so when it decreases. We will know what it is, which was is it endothermic and then when it increases its exo. (Task_Prac)

These extracts show evidence that the learners were thinking while they were doing the practical task, rather than listen to one learner doing all the talking and following her instructions. The learners also failed to use units when they referred to value e.g. '*we know it is 21*", this shows a lack of understanding of physical quantities of units when dealing with scientific concept. Hackling and Fairbrother (1996) argued that discussions are important amongst learners that they will help learners to understand what to do. Learners wanted to have a common understanding as they did the practical task. In the extract above the learners were actually predicting whether the reaction is going to be exothermic or endothermic, just from the temperature changes that they got from the practical task session.

In looking at the sections above, it can be seen that there was enough evidence of what learners were intended to do with objects and observables. On the other hand, there was little evidence of what learners are intended to do with ideas; this further illustrates the level of effectiveness of this particular practical session, which will be discussed later. The other concern was that from this practical session, there was no evidence of learners possessing the aspect of account for observation e.g. proposing a theory.

<u>Level and Nature of learner engagement</u>

Open-ness and Close-ness

The code related to the degree of openness and closeness focuses on whether the practical task is open-ended or closed-ended, whether the learners are allowed to do the practical task on their own or their teacher is demonstrating are the procedure given, interpretation of data by leaners and questions to be addressed in the practical task.

(Open_Clo_C1.1)

The following extracts show the second teacher Mr R, giving his learners instructions that are related to the practical task that they will perform in the next lesson. This instruction followed from the lesson that He presented to introduce the concept of chemical change:

> *Mr R: Right so in the next lesson we are going to carry out an experiment whereby we try to determine whether a reaction is exothermic or endothermic, right?*
>
> *L_S: Yes*
>
> *Mr R: Eh, there are some worksheets here that we are going to use (distributing the worksheets)… Can i give you the instruction there, it says that; 'you have learnt that energy is*

involved in a chemical reaction', right that change of energy is another chemical change… You see in this case there is no method which is given to you, so now you have that paper you go, you form your groups. On Thursday we are doing this practical, you form your groups and try to come up with a method that you are going to use to determine whether the reaction is endothermic or exothermic using these apparatus. Write down your own method, how are you going to determine whether this is endothermic or exothermic using these apparatus, but now you concentrating on pair number 1, 2, 3, 4 and 5, pair number one is HCl and NaOH I'm going to provide that. Now from here you have to form your group, you discuss as a group, ukuthi (that) we are going to do this and this, we are going to draw our table this way and record our results this way and this way. So that when you come you just follow your plan and then you carry out your experiment and then you can interpret it and draw a conclusion from your interpretation. (Mr R_Task_Intro)

The teacher in these extracts gave the learners the instructions of the practical including the worksheets; the worksheet required the learners to formulate their own methods. These extracts show the teachers' objectives; what the teacher wants the learners to learn from the practical task. The teacher also made it explicit that the practical task was an open-ended investigation by saying '*you see in this case there is no method which is given to you*' the teacher indicated that the learner had to device their own method '*try to come up with a method'*. Hackling and Fairbrother (1996) argued that in an open investigation learners given an opportunity to freely choose any method they want to use to address the question of investigation and Mr R engaged his learners in an open-ended task. The teacher went on to guide the learners on what they were supposed to do in preparing for the practical investigation.

On the other hand, one thing that I noted was that Mr R's plans and his implementations did not always align; the initial plan as seen in the lesson preparations and the extracts discussed earlier, indicate that he wanted the practical task to be open-ended as illustrated further in the following extracts:

Mr R: It must be an open investigation, where the learners they must predict what will happen to, first of all to the reaction between water and this without giving the a clue. (Colla_Meet)

The extract above is from the collaborative meeting that we had, where the teachers presented their teaching plans. The teacher wanted the learners to explore the concept on their own, but this ended up not succeeding since they ended up doing a closed ended experiment.

The next section will look at Mr K practical lesson, where he gave instructions to his learners regarding the experiment that they were expected to perform:

Mr K: I will bring the chemicals that you guys are going to use. So what you are going to do is, you are going to classify the types of reactions that we are going to do, I will provide the chemicals as I have said and also a thermometer, right. So what it means is that the initially, at the beginning you need to measure the initial temperatures, right?

L_S: Yes [Chorusing]

Mr K: Now, let me just give, let me have one person per group to just come and get the glass beaker, ah hello (handing out gloves to the students and also the glass beakers). (Task_Prac)

In the extracts above the teacher gave learners the initial procedure of the practical task; this made the task to be closed-ended investigation. It is argued that in a closed-ended investigation all the information is given to the learners and the decisions are made by the teacher (Hackling & Fairbrother, 1996). Mr K told the learners what to do, how to classify the reactions and also the types of chemicals they will be using. The teacher further gave the learners instructions of how to do and report the experiment as illustrated in the following extracts:

Mr K: the important thing for you here is to have the results, make sure that you have the results, draw a table of results, have your initial temperature and your final temperature and as I have said, although it's not it's not the purpose of the experiment to balance the chemical equations. …So the next one that you are going to do, you are going to have water reacting with sodium hydrogen carbonate ($NaHCO_3$). (Task_Prac)

Mr K made it explicit to the learners that this was going to be a closed-ended investigation. The learners were not given an opportunity to devise their own methods and procedures. It is argued that most teachers tend to focus on making sure that learners understood the procedure that they had to follow (Abraham & Millar, 2008).

Mr R was involved in many probes during the practical task session, the following extracts show one of the instances where he was trying to help the learners:

Mr R: Eh what are you aiming to do there, how are you going to, I can see that you have picked up this one (thermometer). How are you going to use this?

L_ E: Measure the temperature.

L_D: Sir, to investigate whether the reaction is exothermic or endothermic.

Mr R: Okay, so when do you measure?

L_D: Haobasiceda uku mixer (when we are done mixing), for example masiceda ukumixer hydrochloride acid neh sodium hydroxide (for example when we are done mixing HCl with NaOH) then sizo (we) measurer I temperature.

Mr R: Then what do expect to see?

L_D: If I high, then its exothermic, if I high yini? If it's high its exothermic, if it's high what is it?) (Task_Prac)

In these extracts the teacher wanted to know whether the learners understood what they were doing by saying '*what are you aiming to do there'*, he wanted the learners to give details of how they will approach the task. Furthermore, he wanted to know how the learners would determine whether what they were measuring was an exo- or endothermic reaction. The extract shows that the investigation was open-ended, the teacher was just trying to guide his learners to see whether they are in the right place or not.

Mr R suggestion of how practical activities can be conduct effectively was that class size should be increased because there are a lot of learners and '*it becomes difficult to manage, you can't find that there are more than 10 learners'* (Inter_Trans). He emphasized that having lab assistance would help in the practical tasks, since they can set up the laboratories in time and help with large classes. In most cases you find that teachers are forced to demonstrate because of the large number of learners in their classroom, which make them open-ended rather than close-ended investigation.

Nature and Level of learner engagement

The second code deals with the nature of learner involvement in the practical task i.e. does the teacher demonstrate and learners observe, does the learner carry the practical task on their own in small groups or is it carried out individually (Millar, 2002).

(Natu_Lear_Invo_C1.1)

The following section shows a discussion that learners had during the practical task:

(Prac_Trans)

L_W: Do you realise that we don't have chemicals here

L_V: We will

L_W: Okay, they must be equal, we don't check. We take the thermometer and then whilst we mixing the chemicals together, obviously if it's endothermic, whatever happens it will go up. So, we will use the thermometer to mix, whilst we pouring water. So that if the chemicals release heat, we will see through the thermometer. We don't care about the room temperature)

L_U: All I'm saying is that we have to know the room temperature

L_V: Yes

L_W: We know that is 21, so when it decreases. We will know what it is, which was is it endothermic and then when it increases its exo.

This extract shows evidence that the learners were thinking while they were doing the practical task rather than listen to one learner doing all the talking and following her instructions. As argued by Hackling & Fairbrother (1996) that discussions are important amongst learners that they will help learners to understand what to do. Learners wanted to have a common understanding whilst they did the practical task. This also shows that the learners were working in small groups, the teacher was not demonstrating in anyway, they were discussing on their own.

When asked about the challenges that he faces when recommending the practical activities, Mr R said the problem was availability of apparatus and he is forced to demonstrate most of the time because of that fact. He further said that when learners are allowed to do practical tasks on their own it becomes a safety concern, because they tend to be playful and *'they end up spilling the chemicals on one another, they get too excited'* (Inter_Trans). This relates to the nature and level of engaging learners in such that, if there is a lack of apparatus, there will not be room for the teacher to involve all the learners. The teachers due to the lack of apparatus might end up demonstrating and the safety concern talks to the fact that the teacher might focus on keeping the learners safe rather than engage them in the practical activity. It is argued that teacher demonstrations may be more effective than practical activities undertaken by learners (Woolnough & Allsop, 1985). The solution that the teacher thought of might benefit his learners at times, as argued above.

When asked about the class size, Mr R said that most classes have around 40 learners and that they vary from grade to grade between the ranges of 36 to 46. This suggests that they often have a lot of learners in one class and this makes it difficult for them to conduct experiment effectively. Mr K pointed out that he has an average of 40 learners per class. This suggests that both teachers have big classes and this makes it difficult when it comes to how they implement practical activities from the CAPS document, the resources might also run out in such big classes. The large number of learners in a class might limit the nature and level of engagement of learners in the practical task session.

When responding to how the learners feel when they are involved in the practicals, Mr K said that they feel '*excited, motivated and encourage'* (Que_Sch). In responding to how he feels when the learners do not understand the purpose of the practical activity. If the learners are excited, motivated and encourage then they will appreciate being involved in the practical investigation. In most cases it is the opposite, the learners tend to not be motivated and they end up not appreciating the involvement in the practical task sessions.

The Practical Context

Duration

The code related to the duration focuses on how long the practical lasts.

(Dur_D1.1)

Mr K when asked about time available for preparing practical activities said that they do not have enough time to prepare for practical tasks, when asked about challenges when recommending practical activities. He said that they are '*given the length of the work schedule'*. Time is seen as a constrain in most schools, the teachers tend to focus on finishing the schedule rather than help learners understand concepts through practical activities. Furthermore, in responding to how learners feel when he uses practical work as part of their learning, Mr R said that '*some learners become happy and ask for more while others say it takes a lot of time*' (Que_Sch).

Mr R pointed out that they do not have enough time in the CAPS training and that even during practical session, the time is not enough to conduct the practical activities. Mr K really emphasized the issue of time; he said they have minimum time to implement what is in the CAPS document because the length of the work schedule is long. Woolnough and Allsop (1985) argued that educators have a small amount of time to explore ways of incorporating wider variety of teaching strategies to match the wider aims in practical work. This suggests that teachers need a large amount of time, for them to use other strategies that might be more effective than others. Learner must be given enough time to develop their own laboratory methods (Berry & Mulhall, 1999), so teachers need a lot of time for them to not only help the learners but also make sure that learners do practical tasks.

People with whom the learners interact

This deals with whether the learners deal with other learners doing the same task or their teacher.

(Peop_Inter_D1.1)

When asked how he promotes conceptual understanding, Mr R said he allows the learners to formulate their own hypothesis, this suggests that he promotes open-ended investigations. When asked about linking content to practical tasks, Mr K said that '*after doing the experiments the kids must relate always, their finding to the content. Otherwise they won't be any purpose of doing the experiment*' (Inter_Trans). Both teachers saw a need to link the content learnt in their classrooms to practical activities, which further suggests that they explore various strategies when teaching. They also saw the need to engage and interact with their learners during the learning and practical sessions.

The following extracts show the teacher intervening in what the learners were doing and talking about with regards to the experiment:

> *L_ U: E kenyemetsing (Put it inside water)*
>
> *L_V: No I tse I drop (it must drop first) [referring to the temperature of the thermometer]. Okay room temperature,waitse ke bokae? (Do you know how much is it?)*
>
> *Mr R: Okay, what are you measuring there?*
>
> *L_U: Atmospheric temperature*
>
> *Mr R: do you need it?*
>
> *L_U: Yes*
>
> *Mr R: why?*
>
> *L_X: Because it's too far*
>
> *Mr R: What temperature, are you measuring the temperature, are you finding if it's endothermic or exothermic?*
>
> *L_V: No! Because it was high, if it measure high it was gonna give us,wantlhaloganya (Do you get me)*
>
> *Mr R: Its initial temperature in a substance?*
>
> *L_V: Sir, it was high, so we are waiting for it to drop*
>
> *Mr R: it can't be zero* (Task_Prac)

In these extracts, the learners were taking measurements of the reactions that they were using. But as I pointed out earlier, the learners had an issue with units, they failed to refer to correct and relevant units when they discussed their measurements. This can imply that the learners did not understand what was happening during the practical session; they just followed instructions not necessarily thinking about other levels of representations. Mr R then wanted to probe the learners' reasoning to see what and why they were doing what they were doing. Mr R saw that the learners were taking a long route and they did some things that were not required of them; he proceeded to guide them to the right answer by asking '*do you need it?*' This was a good approach in the teacher's side, the probing helped some of the learners to go in the right directions and to think critically about some of the challenges that the learners might encounter as they undertake the task at hand. The probe also indicated that the teacher was prepared; he knew what the learners might struggle with during the practical session. It is argued that discussions are important amongst learners and the teacher in that they will help learners to understand what to do (Hackling & Fairbrother, 1996).

In responding to how he links the content to the practical task, Mr K said that he links the result they have collected in the practical task to the theory he teaches, this view is in accordance with Bucat and Cole (1985) who argued that practical work develops from concrete to abstract ideas. According to Mr K, the role of the teacher during the practical activity is '*to facilitate the development of the concepts*' (Que_Sch) and skills at hand. Mr K and Mr R have similar views about the role of the teacher during practical activities, since they both believe that a teacher is a facilitator. Being a facilitator implies that there will be an interaction of some kind between the learners and the teacher during the practical session.

The following extracts show a group of learners who created their own method, who were unable to find the method in their textbook like other group of learners:

> *L_D: Asenze i method, sizokhonaukubona into esiyenzayo (Let's do the method so that we know what we are doing).*
>
> *L_C: [reading the textbook] bathi dissolve about, angazieya. Ah mus okay thinasizothi (we will say) dissolve about 1 of each of the following substances, bese angithi Sisebenzisa (And then we use). Okay le ikhona neh (okay it is here) calcium nayi (here)*
>
> *L_B: Nasi is calcium chloride here is calcium chloride [pointing at the textbook]*
>
> *L_D: nayi (here) soyenzangamanzithina (we going to do it with water) neh calcium chloride (and calcium chloride). Okay ke soyenzange calcium chloride (okay we going to do it with calcium chloride), kusho ukuthi (that means) Lenaangkesiyimixer namanzi I out (we will not mix it with water, it's out), angithisimixer neh lo or sisazoyimixernamanzi (we mix it with... or we mix it with water). Sozimixerzi two besesifakanamanzi? (We mix both then add water?)* (Task_Prac)

In the above extracts managed to formulate their own method and they discussed what to do and were able to agree upon the final method. These learners knew the chemicals that they were supposed to use and they called them by name to indicate that they knew chemicals and how they can be combined in forming products. Hackling and Fairbrother (1996) argued that in an open-ended investigation all the decisions are made by the learners, even the problem.

This suggests that the learners made the practical task to be open-ended, since they created their own methods. This is evidence that the learners were interacting with other learners doing the same practical in their classrooms.

The following extract is from the practical task, were the learners were still conducting the investigation in groups e.g. taking temperatures of the reactions that they were dealing with, at the same time keeping track of the time:

(Prac_Trans)

> *L_T: I two minutes ayikapheli? (Isn't two minutes finished already?)*
>
> *L_S: Ayikapheli (it's not finished), 36 seconds.*
>
> *L_U: Stop!*
>
> *L_Q: Entse (take it out), Ikuphi? (Where is the thermometer reading?)*
>
> *L_S: Iya decreaser (it is decreasing), it's a hundred and ten*
>
> *L_T: It maybe be a hundred and six, so its exothermic neh?*
>
> *L_R: yes*
>
> *L_U: whats the difference guys 106-18*
>
> *Learner U: 92?*
>
> *Learner R: 88*

In the extract above the learners were taking temperatures using a thermometer at the same time keeping track of the time, to make the experiment a fair-test. Despite the focus being on measurements, L_T showed an understanding of what was intended for the learners to understand. She said '*It maybe be a hundred and six, so its exothermic neh?'* and L_R agreeing with her shows that they understand the concept of exothermic. This is evidence of the interaction between learners during the practical session.

The following extracts show the learners discussing how temperature determines whether the reaction will be exothermic or endothermic, before the teacher probed their understanding:

> *L_A: If it's an exothermic, I exothermic Iya releaser? (If it's exothermic the temperature will increase) If it's an endothermic Sir, I think its izofana neh room temperature (I think it's going to be the same as the room temperature) and if it's an exothermic then I temperature izo increaser (then the temperature will increase)*
>
> *L_B: I think it's the other way around*
>
> *L_C: Don't you measure the temperature first, so we know?*

Mr R: Guys, guys order, order, can we have her suggestion

L_B: I was saying don't you measure the room temperature first and from that room temperature we know it's either gonna increase or decrease? The temperature of that things we gonna mix?

Mr R: Guys, guys, I think she's got a point.

L_C: She has got a point (Task_Prac)

In these extracts, the discussion was around when they have to measure the temperature. L_B had a misconception regarding exothermic and endothermic reactions; she said that if it's endothermic, the temperature will increase. von Glasersfeld (1991) asserts that misconceptions are good indicators of how learners think at the moment. This suggests that L_A thought at that moment that increases in temperature means endothermic. L_A on the other hand understood what exothermic and endothermic reactions are. This further suggests that the learners were thinking while they were doing the practical task. The teacher further wanted to guide the learners on what to do when they measure temperature changes. This was mainly influenced by the fact that the teacher knew some of the misconceptions that might arise as a result of learner discussions. The following extracts show Mr K helping the learners with their measurements during the practical session:

Mr K: So did you record the initial temperature?

L_R: ke e, ke 10. (Here it is its 10).

Mr K: you just have to do it this way [stirring the thermometer inside the HCl solution], make sure that it's inside there, you can observe. Who can take note, the group leader? Don't be scared of these things, are you scared.

L_T: Ke 50.

L_ S: Iyatsamaya (its moving)

Mr K: Make sure that the tip of the thermometer is inside there

L_R: Ke sodium hydroxide akere (its sodium hydroxide isn't it)

[Mr K pours NaOH into the solution of HCl]

L_V: keng ke 65? (What is it, is it 65?)

L_R: 65 (Task_Prac)

In these extracts, Mr K was working with the learners through the measurement and making sure that they do the correct measurement, following his method. The issue of units arises further in this discussion i.e. '*keng ke 65*' to indicate that they were not familiar with physical quantities, they had to be specific that its 65 degrees. This falls under level 1: *i*, because the learners were talking about measurements amongst themselves and the teacher. Hackling and Fairbrother (1996) have argued that learners need help to move from recipe style followers to become solvers, Mr K in this case was focusing on the recipe style method, not necessarily helping them to be solvers.

The following extracts are from Mr K consolidation discussion with his learners. He taught energy changes and wanted to relate the concept to an experimental explanation:

> *Mr K: Let's suppose you were doing this experimentally, like what you did there was bond breaking, bond formation. Now if you are using a thermometer to determine the temperature changes, what do you think was going to happen to the temperature here of this reaction? Was there going to be a temperature rise or temperature drop?*
>
> *L_S: Temperature drop.*
>
> *Mr K: a temperature drop, you still now there, this negative. Let's look at this reaction right, if this one is negative, does it mean that we have a net release or net absorption?*
>
> *L_S: Release.*
>
> *Mr K: is this a net release?*
>
> *L_T: absorption.* (Cons_Less)

In the above extracts, the learners showed evidence of being able to recall what they did previously; they were able to know that temperature drop meant net release. This shows recall, whether they understand or not it is difficult to determine at this stage. Mr K also promoted scientific talk in his class by using concepts like bond breakage and bond formation. The teacher also moved the learners through the three levels of representation i.e. micro, macro and symbolic (Treagust *et al*., 2003). By referring to the experiment '*let's suppose you were doing this experimentally'* this represented the macro level and by mentioning bond breakage and formation, this represented the micro level of representation. Johnstone (1982) argued that teachers assume that learners can move easily from one level of representation to another. In this instance the assumption is proven to be true by Mr K, since it was not clear whether all the learners were getting what he was explaining or not.

The following extracts were initiated by Mr K; he tried to link what they did in the experiment to the current topic of energy changes:

> *Mr K: now looking at the reaction that you guys did on Friday, just to sum up. The reactions that you did, is there anyone with the results. The results that you got on Friday, we just want to look at two experiments as I said. Can I have just two results, can I just have one where you have a temperature rise and one with a temperature drop and try to discuss those ones, to sum up the lesson. Just give me one reaction were there was a temperature rise and one where there was a temperature drop.*

L_D: sulphuric acid and sodium hydroxide

Mr K: so it was H_2SO_4 plus sodium hydroxide, to give you what?

Learner E: sodium sulphate

Mr K: sodium sulphate right, and water. For this reaction what was your initial temperature? It was?

Learner D: 20

Mr K: 20 degrees Celsius and what was your T final?

Learner D: 50

Mr K: Okay we are going to talk about the delta T, what is the temperature change here? T final is going to be T final –T initial, so this is going to give us what?

Learners: 30 (Cons_Less)

In the above extracts, the learners indicated that they are able to recall what they did in the previous lesson. The teacher went on to check whether they understood what temperature drop meant:

Mr K: The initial temperature was 20, okay, after the two had reacted, you guys had observed that the temperature had rose to 50. Now what do you say, was there a net release of energy or a net absorption of energy?

Learners: Release

Mr K: net release, right. That's why the temperature goes up, now. How did you classify this reaction? Did you classify it as endothermic or exothermic?

Learners: exothermic

Mr K: as exothermic, right?

Learners: Yes (Cons_Less)

In the above two extracts the learners showed evidence of both recall and some understanding of the concept of exothermic and how it relates to temperature changes. They were able to give an experiment that had a temperature rise. Even though the practical task were closed ended, the learners managed to make links between what they did in the practical task to the theory in the classroom. The learners and the teacher in the consolidation lesson used correct units, while in the practical sessions learners did not make use of any units. This implies that the learners on their own, do not see the usefulness of units when they have to use them on their own, while their teacher tries by all means to emphasize the. This represents level 2: O of effectiveness in that the learners were able to match the temperature drop and rise to the type of reaction, indicating recall of what they did previously. It further showed that the learners whilst they did the experiment, they actually were thinking rather than doing only and showed understanding of the ideas that the task was designed to help them understand (Abraham & Millar, 2008). It is further argued that links between the domain of objects and materials and the domain of ideas, learners often achieve the purpose of laboratory task they need to link and move in between the two domains (Abraham & Millar, 2008).

Information sources available to the learners

The information sources available deals with the sources of information that the learners have at their disposal e.g. textbooks, handbooks.

(Info_Sour_D1.1)

The following extracts indicate Mr K giving the learners instructions of the practical task that learners were required to do. This follows from the introduction lesson that the teacher presented to make learners understand the concept better and one learner asked a clarifying question and Mr K answered:

> *Mr K: More heat, more temperature. I see that concept is tricky, you will understand that when you do the experiment, as i said that we will do experiments on this then, we are going to unfortunately the ones that we are going to do involve temperature changes and you are going to see dropping in temperature and rising in temperatures and its actually going to make sense. So in the next lesson I'm going to bring* ***work sheets*** *to actually see that you are going to use. So that I can see that you guys now understand most of the concepts.* (Task_Intro).

In the extracts above, the teacher saw that the learners had difficulties grasping the concept of heat and temperature. The teacher also made it explicit that the learners were going to use work sheets, which are the sources of information were the learners are going to get an idea of what is required of them.

In the following extracts, the learners were following the teacher's instruction; their teacher wanted them to develop their own methods for doing the practical task:

> *L_K: Sibalaphansi ukuthi be siyenzani (We writing down what we were doing).*
>
> *L_H: Sisebenzisa le ini, le ncwadileya? (What are we using in this book?).*
>
> *L_K: Sisebenzisa (we use it) as the whole experiment, it is exactly what we are doing.*
>
> *L_G: We don't have all of these stuffs.*
>
> *L_K: It's exactly what we are doing; the conclusion will be the same.* (Task_Prac)

The extracts above show the learners discussing about the method they have to use, L_K discovered that the experiment that Mr R gave as an open-ended investigation was actually in their textbooks. The teacher in this case was at fault, since he gave learners a task that was already in the textbook, instead of designing his own open-ended investigation. As a result the learners decided to use what was written in the textbook, rather than to create their own method; by doing that they made this a closed-ended investigation. Furthermore, some of the learners seemed to not have a clear knowledge of the materials and chemicals that they were supposed to use, one learner said '*we don't have all these stuffs*' instead of saying we do not have sodium hydroxide or these chemicals to indicate that she knows what these 'stuffs' are. Clackson and Wright (1992) argued that there are various factors that can lead the learners not to do what they are intended to do with objects and materials and in this instance, the use of a 'recipe style' task or procedure. In this case, if the learners did not get the method from their textbooks, probably they were going to think more deeply about the problem and create their own methods. The textbook was also their source of information. This then turned the practical task that the learners did into a routine and their actions purposeless (Millar *et al*., 2002), since they got the method rather than creating their own.

Following up to the extracts above, the following extracts show another group of learners who also got the method from their textbook:

> *L_X: Di teng (They are here). Ke wo method (Here is the method) ales is there (Everything is there) [pointing into the text book].*
>
> *L_V: Sodium hydroxide, potassium hydroxide, diteng dilo tse (This things are here).*
>
> *L_W: All of them?*
>
> *Mr R: Take note of what you have in that book.*
>
> *L_X: Yes.* (Task_Prac)

As mentioned earlier the learners got the methods from their text book, some decided to use that method rather than create their own method. Surprisingly, Mr R promoted what they were doing by saying '*take note of what you have in that book'*. I thought the teacher was going to tell them to create their own unique method instead of taking the one from the textbook, but that was not the case. The textbook also in this case was the source of information for the learners, since the practical given by the teacher was in their textbook. It is argued that there is sometime a mismatch between the aims of the laboratory task and the actual learners practices (Lunetta, 1998). The teacher in this case did not follow his own objectives, since He said *take note of what you have in that book* even though this was intended to be an open-ended investigation. The investigation changed from being an open-ended to being a closed-ended investigation, because all the information was given to the learners in the textbook (Hackling & Fairbrother, 1996). In avoiding the mismatch between his aims and actual learner practice, Mr R should have created an open-ended method that the learners could follow; this was a missed opportunity by the teacher.

Types of apparatus involved

Finally, the code related to the types of apparatus involved deals with what the learner are being equip with in order to do the practical task.

(Typ_Appa_D1.1).

The following extracts are from the actual practical task, where the learners were taking their measurements using the apparatus and chemicals and talking about them:

> *L_ A: Sir? It is calcium chloride into sodium who now?*
>
> *L_B: Sulphuric acid.*
>
> *L_A: Yes! Its sulphuric acid, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, measure. 31 so it's […]*
>
> *L_B: 81, 91 (holding the thermometer into the beaker with* $CaCl_2 + H_2SO_4$*).*
>
> *L_ A: Oh.*
>
> *L_C: Okay you can remove it ke (then).*
>
> *L_B: (removes the thermometer).* (Task_Prac)

The learners in the above extracts were talking about the measurement and result that they got in the practical task, but again their measurements did not have units. This further indicated that most learners were not aware of physical quantities or it was not emphasized by their teacher. They wanted to get both the initial and final temperature of the reaction between calcium chloride and sulphuric acid. The learner by removing the thermometer shows that she understands that readings might change either increase or decrease if is kept in the beaker for a long period of time. These points to the aspect of conceptual understanding were L_C shows that in order to get accurate results, one has to be considerate of the sudden temperature changes, for one to identify whether it is an exo- or endothermic reaction. Even though it was not explicitly shown in the extracts, the learners were thinking about their measurement and the chemicals that they were using, this is shown by L_B who gave L_A the answer which was *asked to the teacher*. Abraham and Millar (2008) argued that it is difficult for learners to think explicitly about object, because these ideas do not present themselves directly to their sense. In this case, the learners were thinking but it was not visible, since some of them used their gestures to illustrate what they were trying to say.

When asked whether his school is poorly resourced or not, Mr R said that '*it's resourced, but not enough there are some things that are not there. But it's better than other schools'* (Inter_Trans). This suggested to me that the school was resourced and from my observations I could see that the school does have resources such as laboratory and certain chemicals. He further said that they struggle with apparatus because they are difficult to order. When asked the same questions about resources Mr K said that its *'quiet difficult for me to say whether well or poorly, but what I can say is that we do have the minimal equipment that would enable us to do the experiments'* (Inter_Trans). This suggested to me that some resources they do have, while others they do not.

Hattingh *et al*. (2007) argued that there is a relationship between practical work and availability of resource. I further believe that resources on their own do not mean that the practical will be successful, as argued by Hattingh *et al*. (2007) that improving the availability of resources will make little difference if it was not accompanied by interventions. This suggests that teacher interventions are important, the way the teacher uses the resources makes a difference in learner understandings.

.Conclusion

As discussed in the sections below the teachers faced a lot of challenges when it came to doing and implementing the use of practical work in their classrooms. The teachers also expressed their own views about what they think might be the problem when it comes to the implementation of practical work. The discussions above were crucial in giving me an idea of what teachers perceived as the factors that hinder the use of practical work. Furthermore, I believe that despite them having challenges, their perception of their learners is also another factor that contributes to the success or failure of a practical task (Hattingh *et al*., 2007). If the teachers perceive their learners as being 'capable', they will allow them to do practical tasks on their own, while if they perceive their learners as being passive or empty vessels, they will do demonstrations to illustrate concepts to them.

The main challenge is that there are recommended practical tasks which are not necessarily portfolio tasks, the time to do them is minimum because you need time to prepare for practical task. For the teachers to overcome some of the challenges outlined in the above section they will need to be assisted by the government in providing them with what they need and the support they need. Teachers need to take charge of their classes in order to deal with such challenges and also to not rely on the government to help all the time.

In looking at the teachers objectives that were outlined in the previous sections, the teachers wanted their learners to learn and be able to identify an exothermic and endothermic reaction in a given experiment. For example Mr R*: Right so in the next lesson we are going to carry out an experiment whereby we try to determine whether a reaction is exothermic or endothermic* (Task_Prac) and Mr K: *I see that concept is tricky, you will understand that when you do the experiment,. We are going to do one that involve temperature changes and you are going to see dropping in temperature and rising in temperatures and its actually going to make sense.* (Task_Intro). It is argued that learners must be aware of the purpose of practical work as much as their teachers know what they are aiming to achieve (Hart *et al*., 2000). In this case the learners were aware of the purpose of the respective practical tasks.

For both the teachers the level of effectiveness was level 1 from the results obtained, this is because there was a lot of evidence of what learners had to do and they actually did what they were intended to do with objects and materials. The learners had apparatus available to them to complete the practical task and the teachers made it clear what the learners had to do. Mr R allowed his learners to create their own method to follow in doing the practical task, even though they ended up getting the method from their textbooks. On the other hand, Mr K actually gave the learners a recipe style method that they had to follow in completing the task. Both the practical tasks from the teachers ended up being closed-ended in that the most learners followed ‘given’ procedures.

The data that I collected during practical sessions did not provide strong evidence of the effectiveness at level 2 e.g. learning about ideas the task was designed to help understand. The reason for this was that my time for data collection was limited and I could not get learners books to check their progress with regards to the understanding of the concept. The learners showed a lot of recall during the lesson and some evidence of understanding, but not all of them.

The other reason for not seeing the effectiveness at level 2, was that only three lessons each for both the teachers were observed i.e. introduction lesson, practical session and consolidation lesson. For one to know whether the learners have learnt something, one has to observe the learners recalling what they have learnt after a long time. In my observations, the learners seemed to understand what exothermic and endothermic reactions are after just three days after the practical session. This suggested to me that, they could have either grasped the concept or just recalled the concept to be learnt. Finally, it is argued that teachers have an implicit assumption that learners will pick up a tacit understanding of what it means to conduct and plan an enquiry 'scientifically' (Abraham & Millar, 2008). In this case, the learners were unable to pick this kind of understanding. In summary, there were a lot of missed opportunities from my part which could have made my result and discussions even richer than they are.

Main Conclusion

In this chapter I used the analytical framework presented Table 1: *2X2 effective matrix for practical work* to analyse data from the classroom observations. The analysis looked at the effectiveness of tasks at Level 1 (what learners do) and then went on to look at the effectiveness of task at Level 2 (what learners learn). The chapter further analysed teacher's interview transcripts and questionnaire schedules using an interpretative approach, the analysis was guided by a coding system. The profiling of labwork which consists of two major categories regarding practical task i.e. A: *the intended learning objectives* and B: *the key elements of the task design* i.e. cognitive structure of the task, practical context and level and nature of learner engagement was also used in the data analysis and to analyse the data. The next chapter will focus on the conclusion of this study, answering of the research questions and recommendations.

CHAPTER 5: Conclusion and Discussions

Introduction

This chapter presents the summary of findings and discussions and the conclusion of this study supported by evidence, in an attempt to answer the research questions. It further discussed the implications of the study to the South African schooling curriculum. The recommendations and limitations of this study were also being discussed. Finally, suggestions of future studies were discussed.

Research Questions

The main purpose of this study was to investigate how two experienced science teacher, undertaking self-studies to improve use of practical work in their classrooms, developed their strategies for effective use of practical work. The main research question of this study was: *How effective are the two participating teachers' strategies of using practical work to promote conceptual and procedural understanding*? The following were the sub questions to the main:

1. *What perceptions do the teachers hold about use of practical work in teaching science?*
   1.1 What views do they hold about the nature of science?
   1.2 What in the participating teachers' perspectives are some of the factors that hinder the use of practical work in science classrooms?
   1.3 How are the two science teachers relating the content learnt in their science classrooms to the practical work done?

2. *What strategies do they use to promote conceptual understanding and procedural knowledge in their learners?*

3. *How are their professed aims for doing practical work aligned with what actually transpire during the actual classroom implementation?*

Discussions and Summary of Findings

The following section answers the research questions using the discussions from chapter 4 with reference to critical instances that were discussed in that chapter.

1. *What perceptions do the teachers hold about use of practical work in teaching science?*
   1.1 What views do they hold about the nature of science?
   1.2 What in the participating teachers' perspectives are some of the factors that hinder the use of practical work in science classrooms?
   1.3 How are the two science teachers relating the content learnt in their science classrooms to the practical work done?

In answering these questions, one needs to consider the interview and questionnaire schedules. The question 1.2 can also be answered considering the section of intended objectives, were the teachers discussed their plans in two categories i.e. content and process. Both the teachers seemed to have the same factors that they thought hinder the use of practical work in their science classrooms i.e. inadequate CAPS training, time constrains, class sizes, resources and discipline. Regarding CAPS training, the teachers mentioned that they attended three times each. They did not have enough training to understand the document, Mr R stated that some things he learns from the training while others he discovers himself. The teacher had to discover things on his own whilst he was teaching, instead of focusing on learner understanding. Mr K said that what is in the document will not always be covered, so important aspects are the main focus in the CAPS training. Both teachers said that if they had enough training, then they would be able to implement and use practical work effectively in their lessons.

The teacher also mentioned time constrains, Mr K said that his challenge was that there were recommended practical activities that were not portfolio tasks and that the time needed to do them was minimum since they were working under a tight schedule. Mr K further said that they do not have enough time to prepare for practical tasks. Both teachers emphasized on the length of the periods saying that the periods are too short and that they are forced to do the practical activities during free periods. This suggests that time is a factor in hindering the use of practical work in classrooms. The teacher's main challenge seemed to be lack of resources, Mr R said the problem was availability of apparatus and he is forced to demonstrate most of the time because of that fact.

The schools that the teachers were teaching at had limited resources, from my observations they were resourced but not fully. I could see in both schools that they do not have enough resources to perform most of the prescribed experiment in the CAPS document.

The teacher further complained about class sizes as being too large, Mr R said that most classes have around 40 learners and that they vary from grade to grade between the ranges of 36 to 46. This suggests that they often have a lot of learners in one class and this makes it difficult for them to conduct experiment in a correct manner. The final factor mentioned was discipline, Mr K pointed to the lack of discipline when learners are doing practical tasks. He further pointed out that discipline is a problem because learners become so excited that they loss focus of what you are doing. Discipline also causes safety issues because as Mr R said they tend to be playful. In answering the question the factors that hinder or might hinder the use of practical work in science classrooms are time constrains, inadequate CAPS training, large class sizes, lack of resources such as chemicals and apparatus and lack of discipline amongst learner as discussed in the above sections. The teachers strategies are effective in that learners during the course of the study showed both conceptual and procedural understanding, mainly procedural understanding.

In answering the question 1.3 of relating content and practical, I considered what teachers said about relating content to practice and what they actually did in their classroom interventions. In the interviews and questionnaires, the teachers had to answer questions that were related to how they link the content they teach to the practical activities that they perform in practical tasks. When both teachers were asked how he links content and practical tasks in the interviews, Mr R stated that it depended on the topic, other times he demonstrates and sometimes they start with a lesson then use the experiment to verify the concept. Mr R further pointed out that you can sometimes start with the practical task and then follows with teaching the content. While, Mr K stated learners must always relate the experiment to the content they learn in classroom. This relates to the link between content and practical tasks. Both teachers saw a need to link the content learnt in classrooms to the practical activities done in practical sessions.

In the questionnaire schedules, both teacher when they responded to how they relate the content taught to the practical activity in their classroom, Mr R stated that he reminds the learners of the known and help them to link what they know to new concepts. These talks to the aspect of linking the content to the theory, on the other hand the teacher demonstrated less of the link when I observed him. Mr R further said that he introduces the topic, gets the learners prior knowledge and then the learners do the practical activity to verify their theory. On the other hand, Mr K said that he links the result they have collected in the practical to the theory. Even in the questionnaire, the teacher felt a need to introduce the concept and then does a practical activity to enable learners understand the concept better.

On the practical level, the two teachers involved in this study used three intervention lessons (refer to appendix 9), the first was an introduction lesson; this was the lesson that introduced the topic to be learnt by the learners. They then had a practical task lesson; where the learners had to engage in a practical task in exploring or ‘proving’ the concept practically for better understanding and referring to what they had done in the introduction lesson. Finally, the teachers had a consolidation lesson, that reflected on the practical task and ‘checked’ what the learners had learnt from the practical task, whether they have learnt what the teacher intended the learners to learn or not. The teachers both used the introduction lessons to introduce the topic that they wanted the learners to do. They then did the practical task to make the concept ‘real’ to the learners, so that they understand what the concept meant. They finally brought everything together in the consolidation lesson, where they explained how what they did in the introduction lesson relates to what they did in the practical tasks. For them to know whether they have related the concepts to the practical task, they asked the learners questions in the consolidation lesson to check whether they understood or not. In chapter 4 it was clear how the teachers linked the content to the practical tasks and there was an alignment between their objectives and practical task they provided to the learners. . The two teachers can either started with demonstrations and then explained what they were demonstration e.g. practice-to-theory. On the other hand, they can use what I call the ‘three lesson intervention’, were they start with introducing the concept and then perform the practical task as they did during the data collection process and finally have a consolidation lesson to explain how the concept relates to the practical task e.g. theory-to-practice. In summary the teachers used practical task to link to the content that they teach and their strategies were guided by specific topics that they taught.

2. *How are their professed aims for doing practical work aligned with what actually transpire during the actual classroom implementation?*

In answering this question, one has to consider the analytical framework in Table 1: *2X2 effective matrix for practical work* from the previous chapter. This framework considers the teachers objectives against what the learners actually learn (Abraham & Millar, 2008). The framework starts by looking at the effectiveness of tasks at Level 1 (what learners do) and then looks at the effectiveness of task at Level 2 (what learners learn). The other section that needs to be considered is the nature and level of engagement section, where the teacher and the learners were working hand in hand to complete the practical activity and also the practical context section, were the learners and the teacher were engaging with one another in understanding the aim of the practical session. Both the teacher intended the learners to learn about energy changes and also identify an exothermic and endothermic reaction in a given experiment. They both made their objectives clear to their learners and tried by all means to make sure that the objectives are fulfilled. Despite all this, there were some challenges that either hindered or promote the use of practical work. The intended objective section can also be considered in answering this question and also the section of openness and closeness of a practical activity can be considered when answering this question.

The important question at the moment is whether what the teachers intended the learners to learn, they actually learnt. For both the teachers the level of effectiveness was level 1 from the results obtained, this is because there was evidence of what learners had to do and they actually did what they were intended to do with objects and material. The learners had apparatus available to them to complete the practical task and the teachers made it clear what the learners had to do. The data that I collected during practical sessions did not provide strong evidence of the effectiveness at level 2 e.g. *learning about ideas the task was designed to help understand*. This suggests that there was little evidence to prove or show that the learners actually learnt what they were intended to learn.

Furthermore, the other reason to not seeing the effectiveness at level 2, was that only three lessons each for both the teachers were observed i.e. introduction lesson, practical task session and consolidation lesson. For one to know whether the learners have learnt something, one has to observe the learners recalling what they have learnt after a long period of time. In my observations, the learners ‘seemed’ to understand what exothermic and endothermic reactions are after just three days after the practical session. This suggested to me that, they could have either grasped the concept or just recalled the concept.

In answering the research questions, the two teacher’s aims were sometimes aligned to their practical task, but sometimes they were not aligned. The reason for this was that what they planned to do in their lesson plans, they did not managed to do in most cases. This suggests that their aims are not directly aligned to their classroom implications or interventions. This further suggests that what they aimed to do was done, but not satisfactory. The other missed opportunity that I have pointed out earlier, I did not get a chance to look at the learners written work. If I had seen their work, I would have been able to see whether their objectives are aligned to what is happening in the classroom.

3. *What strategies do they use to promote conceptual understanding and procedural knowledge in their learners?*

The strategies that the teachers used can be seen in their planning and during their implementation, in the section of intended learning objectives the teachers were outlining their plans and in the implementation, one can refer to the nature and level of engagement and practical context section in order to get the strategies used to promote conceptual and procedural knowledge in their learners. The teachers used the '*three lesson intervention'* as a strategy for promoting both conceptual and procedural understanding, where they had an introduction, practical task and consolidation lessons in an attempt to help their learners not only to grasp the concept but also to relate content leant to practical activities done. During the practical sessions, the teachers used certain strategies to promote both conceptual and procedural understanding, most notably conceptual understanding. As mentioned in the previous question, the teachers used the 'three lesson intervention' in relating the content to the practical activity; this implies that when the learners are able to relate the content to practice, they might understand conceptually. The teachers promoted conceptual understanding by allowing their learners to do the practical tasks on their own and make decisions that will allow them to make links between the content and the practical tasks.

What Learners do with Objects and Materials is the level that one has to look at when considering procedural understanding; this is because this aspect focused on what the learners did with the apparatus and chemicals that they had in their possession. The teachers had different strategies when it came to the promotion of procedural understanding, Mr K showed the learners what to do and helped them with how they can use the objects and materials that they had in their possession, he used a 'recipe style' approach were the learners are told step by step what to do. Mr K used a 'discovery learning' approach as a strategy. What he did was allow his learners to formulate their own methods to doing the practical task, which enabled the learners to think about the procedures that they would employ during the practical task.

This particular teacher by using this strategy promoted both the conceptual understanding in the consolidation lesson and procedural understanding in the practical task lesson, in enabling them to formulate their own methods and execute them in the process. The learners in the respective classrooms were able to execute the experiment without any struggle; this suggests that they understood the procedural part of the experiment. And the fact that there was some evidence of effectiveness at level 2 in both the teachers' lessons indicates that there was conceptual understanding. Furthermore, both teachers at some point allowed their learners to help one another without them being involved, for the learners to gain procedural understanding.

When asked in the questionnaire how he promotes conceptual understanding, Mr R said that he allows his learners to formulate their own hypothesis; this suggests that he promotes open-ended investigations. While Mr K stated that there is a need to link the content to the practical, otherwise the purpose of the experiment will not be fulfilled. This suggests that both teachers tend to make their lessons to enable their learners to make links between the content learnt and the practical task done, which often result in the gaining of conceptual and procedural understanding.

Conclusion

This study has shown the effectiveness of practical work in some South African classrooms, it has also shown what Hodson (1990) meant when he argued that practical work is often ill-conceived, confused and unproductive. The study has also revealed how some teachers in South African schools go about their daily teaching and how they engage in practical activities with their learners. The two practical sessions that were observed in the two classrooms have suggested that the practical tasks used by the teachers were generally not effective to see the task in a scientific perspective (Abraham & Millar, 2008). The learners generally followed the instructions, but did not engage more in-depth with the science behind the practical tasks. The lesson that was learnt from this study is that science teachers need consistency in the approaches that they employ, which values practical work for the improvement of science learning by the learners (Berry & Mulhall, 1999).

This study has shown that linking the content to the practical activity is useful in enabling better understanding of the concept. It has shown that conducting practical activities can be done even if the teachers have limited resources. The learners in this study have really showed enjoyment and excitement when they were being involved in practical activities, this calling for a need for teachers to engage in more practical activities with their learners. This study similar to that by Abraham and Millar (2008) has suggested that the use of practical work has potential in improving the need to recognise that explanatory ideas do not 'emerge' from observables and ideas. This suggests that learners can gain explanatory ideas from other aspects of practical work other than observation and ideas.

The project also provided a clear view of the nature of practical work and how it can be used effectively by other science teachers.

In addition the project showed how the use of practical work can help learners in relating content learnt to the practical tasks done in laboratories. This project was also of benefit to the participating teachers as I was a sounding board as well as a critical friend during our team research sessions. The learners in their classrooms hopefully also enjoyed and benefitted from this work as their teacher's capacities to use practical work improves. Finally, this project hopefully provided insights on how the South African school curriculum and learner performances can be improved through effective use of practical work.

This study also made it clear that some South African schools have challenges which hinder the use of practical work and learning in general. It is stated the confidence of teachers need to be boosted for them to operate competently (Stoffels, 2005). This can be done by providing them with the necessary apparatus to do practical activities and further equip them with all the teaching and learning materials and training that would promote learning and teaching in their classroom and allowing the learners to gain both procedural and conceptual understanding.

Implications for the Curriculum

This study has revealed the challenges that some teachers face as they implement the use of practical work in their classrooms, the CAPS document need to find ways of helping these teachers to overcome the challenges that they face. The South African schooling curriculum needs to be designed in a way that it supports the teachers, instead of giving them a tight schedule. Teachers should be made free to explore other strategies in their classrooms. The science curriculum especially needs to be made more practical, the CAPS document should have more practical activities for learners to be able to understand concepts better. The curriculum must also be designed in such a manner that when teachers have to conduct practical activities, those activities require simple and basic resources for them to be done. As argued by Rogan and Grayson (2003) South African is in a risk of falling into a trap, were they design visionary and educational policies for the national curriculum on the other hand they do not provide ways of how these can be implemented.

Recommendations

As seen in this study the use of practical work in science classroom has positive outcome, there are some challenges that teachers face at the same time. Rogan and Grayson (2003) argued that the change in the practices of teaching and learning should be viewed as a change in the culture not a technical matter. This suggests that the teachers need to change the way they do things, if they see that an approach is not working they should try out other approaches. Teachers need to further receive advice and accept help from other institutions; they should not think that because they have been teaching for 10 to 20 years they cannot improve the way they do things.

Teachers should also attend workshops regularly, they should not attend them just to make their bosses happy, but they should attend them knowing that they will benefit something from them. Rogan and Grayson (2003) argued that if educators attend the workshops but fail to implement what was taught, then they will not change their approaches. The government and the Department of Basic Education should provide teachers with basic resources and laboratories for them to be able to conduct informal and formal task as suggested by the CAPS document. The department should also provide teachers with lab assistance to help around the lab in setting up apparatus and assisting the teachers with large class sizes. In cases where there are no resources, teachers should learn to improvise in order to conduct basic demonstrations in their classrooms. The teachers need to also be provided with more CAPS training in order for them to familiarise themselves with what is in the document and how to implement whatever is in the document.

Limitations

The sample of this study was small; this study only had 2 teachers and 2 schools, this means that I cannot therefore generalise. The lessons that I observed were also few, I observed 6 lesson in total. If more lessons were observed, then my data could have been rich and I could have gotten better results that what I had currently. The fact that both the participant teachers were current honours student, made my data to not show a typical teacher in a regular school, most teachers only have their degrees or diplomas. A typical teacher in South African school has in most cases a degree and teachers a very large number of learners approximately 40-80 learners in a class, especially in public schools. There were a lot of missed opportunities when it came to my data collection, the fact that I did not get learners workbooks limited my discussions. This further suggests that the results that I got from this study only represent some teachers who teach in urban areas and have furthered their studies not all the South African teachers.

Suggestions of Future studies

This research study has taught me a lot of things about research i.e. patience, hard work and dedication. For future studies, I would have a bigger sample with more schools and more teachers to investigate the effectiveness of practical work in schools. I would also want to explore the differences in the effectiveness of practical work between urban and rural schools, because I believe that the effectiveness would be different from these two types of schools. In the future, I will mix the teachers according to their race, gender and background, to explore how different the challenges they face are.

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APPENDICES

Appendix 1: INFORMATION SHEET LEARNER

Dear Learner

My name is *Kabelo Sitole* and I am an MSc student in the School of Education at the University of the Witwatersrand.

I am doing research towards my MSc in science education degree and the title of my research is: *A cases study of two experienced science teachers' use of practical work.*

This study is about improving strategies of using practical work to promote science learning in classrooms. Your teacher, Mr ** is part of a collaborative research team and in this research we will work together to reflect on how best he can use practical work to help you understand science better. As part of that process, I therefore seek permission to audio and video record your science lessons as well as use your assessment tasks, as a way of collecting data. This research will have a good contribution to your own learning as we will engage in continuous feedback process to support your science teacher as he endeavor to improve his science teaching strategies.

I plan to visit your school over the course of one week for observations and data collection. I assure you that, this study will not interfere with the normal running of the school and you as a learner will not be disadvantaged in any way as a result of participating in this study. I also reassure you that at any time during this project, you have the right withdraw your permission, and no penalty will be imposed on you.

The results of this study will only be used for academic purposes and your name and the identity of your school will be kept confidential at all times in all reports. Your individual privacy will also be maintained in all published and written data resulting from the study. All research data will be destroyed between 3-5 years after completion of the project.

Your parents have also been informed and their permission has also been sought, but at the end of the day it is your decision to join us in the study.

I look forward to working with you!

Please feel free to contact me if you have any questions.

Yours sincerely,
Kabelo Sitole
Email: Kabelosolly@gmail.com
Cell number: 0725628027

Learners Consent Form

Please fill in and return the reply slip below indicating your willingness to be a participant in my voluntary research project called:

I, ________________________ give my consent for the following:

Permission to observe you in class

I agree to be observed in class. YES/NO

Permission to be audiotaped during interviews

I agree to be audiotaped during the interview YES/NO

I know that the audiotapes will be used for this project only YES/NO

Permission to be interviewed

I agree to be interviewed for this study. YES/NO

I know that I can stop the interview at any time and don't have to Answer all the questions asked. YES/NO

Permission to be videotaped

I agree to be videotaped in class. YES/NO

I know that the videotapes will be used for this project only. YES/NO

Informed Consent

I understand that:

- My name and information will be kept confidential and safe and that my name and the name of my school will not be revealed.
- I do not have to answer every question and can withdraw from the study at any time.
- The videos taken will be edited to prevent anyone from recognizing me
- I can ask not to be audiotaped or videotaped
- All the data collected during this study will be destroyed within 3-5 years after completion of my project.

Sign______________________________ Date____________________________

Appendix 2: INFORMATION SHEET TEACHERS

Dear ____

My name is *Kabelo Sitole;* I am a Masters student in the School of Education at the University of the Witwatersrand. I am doing research towards my MSc in science education degree and the title of my research is: *A cases study of two experienced science teachers' use of practical work*

Surely you are aware that potentially, practical work can serve as a great strategy to promote both conceptual and procedural knowledge of learners but, research in this field has revealed that this is complex and very difficult to achieve, resulting in its ineffective use in most classrooms.

In this research I am hoping to work with you as an experienced physical science teacher, carrying out a self-study to improve your own strategies of using practical work, and my aim will be to explore the potential of its use in teaching of science concepts, within the context your study. The reason why I am interested in this study is because I also carried out a self-study looking at my own strategies of supporting natural science pre-service teachers during their practical sessions, and would like to explore the potential use of practical work deeper.

In this study, mine will partly be to serve as a sounding board as well as a critical friend, throughout the process, as you endeavor to improve your strategies in effective use of practical work. I am therefore seeking permission to come and work with you and your learners, and as part of my data collection process, to audio and video record your teaching, as you implement your research lessons. I also seek permission to use your lesson plans, teaching arte facts, interview you as well as request that you complete some questionnaires as part of this process.

No doubt that as a researcher carrying self-study yourself, you will appreciate that from both research and teaching perspective, this research will have a good contribution to your own work as you endeavor to improve your strategies of using practical work for learners' conceptual and procedural understanding. I am also hopeful that as a team we will be able to come up with studies that can shed light which can be used to improve science teaching in our country.

I plan to visit your school over the course of one week for observations and data collection. I assure you that, this study will not interfere with the normal running of the school and that you and your learners will not be disadvantaged in any way as a result of participating in this study. You and your learners are reassured that you can withdraw permission at any time during this project without suffering any penalty.

The results of this study will only be used for academic purposes and your names as research participants in this study, as well as identity of your school, will be kept confidential at all times in all reporting about the study. Your individual privacy will be maintained in all published and written data resulting from the study and all research data will be destroyed between 3-5 years after completion of the project.

Please let me know if you require any further information. I look forward to your response as soon as is convenient.

Yours sincerely,
Kabelo Sitole
Email: Kabelosolly@gmail.com
Cell number: 0725628027

Teacher's Consent Form

Please fill in and return the reply slip below indicating your willingness to be a participant in my voluntary research project called:

I, ________________________ give my consent for the following:

Permission to observe you in class

I agree to be observed in class.	YES/NO

Permission to be audiotaped during interviews

I agree to be audiotaped during the interview	YES/NO
I know that the audiotapes will be used for this project only	YES/NO

Permission to be interviewed

I agree to be interviewed for this study.	YES/NO
I know that I can stop the interview at any time and don't have to Answer all the questions asked.	YES/NO

Permission to be videotaped

I agree to be videotaped in class.	YES/NO
I know that the videotapes will be used for this project only.	YES/NO

Informed Consent

I understand that:

- My name and information will be kept confidential and safe and that my name and the name of my school will not be revealed.
- I do not have to answer every question and can withdraw from the study at any time.
- The videos taken will be edited to prevent anyone from recognizing me
- I can ask not to be audiotaped or videotaped
- All the data collected during this study will be destroyed within 3-5 years after completion of my project.

Sign______________________________ Date____________________________

Appendix 3: LETTER TO THE PRINCIPAL, SGB Chair, etc.

Dear ___________________________________

My name is *Kabelo Sitole;* I am a Masters student in the School of Education at the University of the Witwatersrand. I am doing research towards my MSc in science education degree and the title of my research is: *A cases study of two experienced science teachers' use of practical work*

Potentially, practical work can serve as a great strategy to promote both conceptual and procedural knowledge of learners but, research in this field has revealed that this is complex and very difficult to achieve hence many science teachers in most classrooms, struggle with its effective use. In this research I will work with two experienced physical science teachers with the aim of exploring the potential of effective use of practical work in teaching of science concepts. As you would be aware, Mr ** is also pursuing his post graduate studies and therefore the two of us are part of a collaborative team which is aimed at exploring effective use of practical work in schools. I am therefore inviting your school to participate in this exciting venture.

As part of this research, I seek permission to come and work with Mr ** and his grade ** learners during his physical science lessons. This will involve audio and video recording of the lessons, use of his lesson plans and assessment tasks, as a way of data collection for our research in improving strategies of using practical work in science classrooms. I will also interview and request Mr** to complete the relevant questionnaires as part of this process.

From the learning perspective, this research will have a good contribution as we will engage in continuous feedback process to support Mr ** as he endeavor to improve his science teaching strategies. One other reason why I have chosen your school is because it is a highly functioning school. I hope that the benefits derived from this research will eventually be implemented to improve learning and teaching of science in your school as well as other progressive schools in our country.

I plan to visit your school over the course of one week for observations and data collection. I assure you that, this study will not interfere with the normal running of the school and that your learners will not be disadvantaged in any way as a result of participating in this study. The learners and the teacher will also be made aware and reassured that they can withdraw their permission at any time during this project without suffering any penalty.

The results will only be used for academic purposes and names of the research participants and identity of the school will be kept confidential at all times in all reporting about the study. Your individual privacy will be maintained in all published and written data resulting from the study and all research data will be destroyed between 3-5 years after completion of the project.

Please let me know if you require any further information. I look forward to your response as soon as is convenient.

Yours sincerely,
Kabelo Sitole
Email: Kabelosolly@gmail.com
Cell number: 0725628027

Appendix 4: Ethics Letter

WITS SCHOOL OF EDUCATION

27 St Andrews Road, Parktown, Johannesburg, 2193•Private Bag 3, Wits 2050, Johannesburg, South Africa
Telephone: +27 11 717 3007 • Fax: +27 11 717 3009 • Website: www.wits.ac.za

Student Number: 476826

Protocol Number: 2014ECE043H

26 May 2014

Dear Kabelo Sithole

Application for Ethics Clearance: **Bachelor of Science with Honours in Science Education**

Thank you very much for your ethics application. The Ethics Committee in Education of the Faculty of Humanities, acting on behalf of the Senate has considered your application for ethics clearance for your proposal entitled:

Exploring the use of Practical work to develop learner's conceptual and procedural understanding in Chemistry- A self study

The committee recently met and I am pleased to inform you that clearance was granted.

Please use the above protocol number in all correspondence to the relevant research parties (schools, parents, learners etc.) and include it in your research report or project on the title page.

The Protocol Number above should be submitted to the Graduate Studies in Education Committee upon submission of your final research report.

All the best with your research project.

Yours sincerely

MMabeta

Matsie Mabeta
Wits School of Education

011 717 3416

CC Supervisor: Ms Mpunki Nakedi

Appendix 5 - Observation Schedule

Place: ______________________________

Time: ___________________________

Setting: ____________________________

My Role as the observer: _____________________

Does the school have a Laboratory? Yes/No ________________________________

Does the school have Electricity? Yes/No ________________________________

Does the school have Water Yes No _______________________________?

Does the school have Laboratory equipment Yes No ________________________________?

<u>Actual Classroom Observation</u>

The teacher explains to the learners what needs to be done in the practical task.

10 min	15 min	20 min	25 min	30 min	35 min	40 min	

Learners gather apparatus to do practical work.

10 min	15 min	20 min	25 min	30 min	35 min	40 min	

Learners are doing practical work.

10 min	15 min	20 min	25 min	30 min	35 min	40 min	

Learners discuss the practical work in groups.

10 min	15 min	20 min	25 min	30 min	35 min	40 min	50 min

Learners clear away the apparatus

10 min	15 min	20 min	25 min	30 min	35 min	40 min	50 min

Appendix 6 – The Interview Schedule

1. How many years have you been teaching Sciences (Physical Science, Natural Science or Life Science)?

2. What is the highest qualification do you have?

3. Do you attend the CAPS training? If yes, how often do you attend?

4. Does CAPS training prepare you as a teacher to adequately for implementing CAPS in the Grade(s) that you are teaching?

5. Does the CAPS document suggest prescribed and recommended practical activities? How are they different from one another?

6. What are some of the challenges you encounter when doing the prescribed practical activities from the CAPS document?

7. How do you overcome the challenges you face(s)?

8. Have you done any of the recommended activities?

9. What challenges did you encounter when doing the recommended activities?

10. How did you overcome these challenges?

11. Is your school well-resourced/poorly-resourced in terms of science Laboratory equipment's? Elaborate.

12. What suggestions would you provide on ways in which science practical work can be conducted effectively in your school/classroom?

13. How often do you link the content that you teach with the practical activities done by learners?

14. How many learners are normally in your classroom during when doing practical activities?

15. When implementing the use of practical activities in your classroom, do your objectives of the task get done successfully by the learners?

16. During the implementation of practical activities from CAPS, what are some of the strategies you employ to enable learners to understand the concepts intended in the practical activity?

Appendix 7: The Questionnaire

Section 1: Purposes attributed to practical work

1.1. In practical activities, what is the importance of learner observations?

1.2. In science classrooms, during practical activities, how important is the use of apparatus by learners? (e.g. a thermometer)

1.3. In practical activities, how important is collaboration amongst learners (e.g. group work)? Explain your answer.

1.4. How can you link the content you taught in classrooms to the practical activity done in laboratories? Explain your answer.

1.5. What is the role of the teacher during a practical activity?

1.6. What is the role of the learners during practical activities?

Section 2: Attitudes towards practical work

2.1. When doing practical activities, how do you feel when learners ask things you do not know and make you feel uncomfortable?

2.2. What are some of the reasons that would make practical activities to not go as planned? Explain your answer.

2.3. How do you think learners feel when they are involved in practical tasks?

2.4. How does it make you feel when learners do not understand the purpose of the practical activity?

2.5. How do you think learners feel when you use practical activities as part of your teaching?

2.6. How do you feel when you do not have appropriate or enough apparatus for doing practical activities?

Section 3: Perceptions of engagement and control

3.1. When conducting practical activities do you follow the activities in the textbook or design your own?

Strong Agree	Agree	Neutral	Strongly disagree	Disagree

3.2. I have to conduct practical activities in my science classes, although I don´t like them.

Strong Agree	Agree	Neutral	Strongly disagree	Disagree

3.3. I always make sure that I refer to previous content when learners engage in practical tasks.

Strong Agree	Agree	Neutral	Strongly disagree	Disagree

3.4. Learners talking during practical tasks mean that they are learning.

Strong Agree	Agree	Neutral	Strongly disagree	Disagree

3.5. Learners not asking questions mean that they understand what they have to do.

Strong Agree	Agree	Neutral	Strongly disagree	Disagree

3.6. Learners gain understanding of conceptual aspect of the practical activity.

Strong Agree	Agree	Neutral	Strongly disagree	Disagree

Section 4: Subjective experience

4.1. When conducting practical activities I feel...

Organized

Strong Agree	Agree	Neutral	Strongly disagree	Disagree

4.2. Dominant

Strong Agree	Agree	Neutral	Strongly disagree	Disagree

4.3. Stressed

Strong Agree	Agree	Neutral	Strongly disagree	Disagree

4.4. Frustrated

Strong Agree	Agree	Neutral	Strongly disagree	Disagree

Section 5: The Nature of Science

5.1. What do you think is an experiment?

____
____
____
____
____
____
____
____

5.2. In your own opinion, does the development of scientific knowledge require experiments? If yes, explain why. Give an example to defend your position. If no, explain why. Give an example to defend your position.

5.3. Is Science based on experiments? Explain your answer.

5.4. Is there a difference between a scientific theory and a scientific law? Illustrate your answer with an example.

5.5. In your view, what is science? What makes science different from other disciplines? Explain your answer by giving examples.

5.6. Is there a difference between a scientific knowledge and opinion? Give an example to illustrate your answer.

Thank You.

Appendix 8: Transcriptions

Introduction for Reason

Mr R: chemical change, let just think about that word and try to find out what do you mean by chemical change, are there some changes in chemicals? Think about it, anything that you think, if there are some changes in chemicals when are those changes taking place and which are the changes. So those are the questions that you can ask yourself, chemical change are there any changes in chemicals, if they are there what are those changes, just think about that one and then you give me your opinions and then we put them on the board and we can also link this with what we have learnt previously, right, any idea that you have about that word, chemical change? Anything that you think of, yebo?

Learner A: i think is the change of chemicals from one phase to the other

Mr R: change of phase right, you are talking about change of phase, yes, eh yes, there is change of phase

Learner B: chemical reactions

Mr R: right he says chemical reactions; he says chemical change is about chemical reactions what else

Learner B: interrelation of substance, other substances

Mr R: interrelation of?

Learner B: substances

Mr R: substances, right interrelation of substances right, is reaction, okay let me just put that one (writing on the board: *Interrelation of substances*), right, let's say you are using these 3, when do we observe or when do we see the interaction of substances?

Learners: [During chemical reactions]

Mr R: during chemical reactions, right and then when does this change of phase occur? During a chemical reaction, it can occur during a chemical reaction or?

Learners: change of phase

Mr R: change of phase can also occur, just heat a substance, right now let's go to chemical reaction. Let me just put one example, let say i say H2 plus O2, we get a product there, one of the product we can get is H2O, right. So what do we start with here, we start with two chemicals which is hydrogen and oxygen and then we get that water, right and i go to this interaction of substance, this is a substance and this is a substance, so in order for us to come up with water what should happen to this? What? Hands up? Right lets balance this first 2 here, here? Where? Here? Right, so you have balance that equation, so now we have this O2 and that H2 we want to get that water , what should happen to this two substances before we come up with water? They must what

Learners C: they must bond

Mr R: they must bond, right what is this it's a molecule, this is a molecule, look at this we are having H2, how many molecules, they are two combined with what, one yes, in this molecule only when they are two molecules, in that molecule how many molecules are there?

Learners: two

Mr R: combined with what? One, you see, in other words, so in drawing this from grade 10 i can have H, H and another what, this is a molecule, that's what that equation says, and then we are adding it to what O,O, O2, this two is joint together remember. And then what do we have here, we have an O with two H's, there but now in order to have this, what must happen to this two molecules, they must bond? They just come and bond here, right. Yes i understand but now my question is, let me take this. Let me take this its O, O, i take that, i just bond hey...

Learners: [laugh]

Mr R: do you see what I'm coming up with?

Learners: Yes

Mr R: is this the same as this?

Learners: No

Mr R: so, what the problem there, look here what must happen first?

Learner B: I think they should share valence electrons

Mr R: Jah, then? Remember sharing can occur, can we share and have 2O with H, so what must happen first to these? They must what? Say it?

Learner A: they must un-bond

Mr R: they must un-bond

Learner A: they must separate

Mr R: they must separate yes, yes that's the thing

Learners: [Ohh][laughing]

Mr R: you understand?

Learners: yes

Mr R: guys this is a change that we are talking about, now this one has changed, this is has changed its no longer an H2 or O2, it’s now H2O it’s one of the changes that you are talking about when we are talking about chemical change, there are changes that take place the chemical that we start with will change, maybe by breaking to form atoms first then those atoms will rearrange to form a new substance, you see, so that’s the chemical change, there is a lot of what is happening inside the container, those O2 must first of all break because they cannot just [..] their O2, it can’t happen> first of all they break we have separate atom, those separate atoms rearrange and form knew what? Molecules, then we got a new substance, a chemical change has taken place there, so what are the chemical change that we talking about? Rearranging of what? The substances that we started with to form what new substances, right. For example can list this process, from here we can have these breaking into atoms, now we have atoms that are different, remember this is inside the same container, right. Now we have these O they are so many of them as well, these now rearrange, these two join with one, to form what?

Learners: H2O

Mr R: and then these two will also join with another O, to form what H2O, so from these we get two H2O’s, so they will be another H2O, so that why we are saying these are two molecules of water that are formed they are formed from this, so that’s the chemical change that we are talking about. So from this stage they break and rearrange and then they join and form that. Okay, now someone talked about bonding, yes? Who can define bonding for us? You say they bond? Yes?

Learner B: sharing of atoms between two atoms

Mr R: sharing of atoms between?

Learner B: two atoms

Mr R: that is another type of bonding, but i want to add, what is bonding before we go to different types ye,

Learner E: [....]

Mr R: sorry

Learner E: i said it’s the force of attraction between ions

Mr R: it’s another type of bonding, bonding between two ions. It’s another type of what?

Learners: Bonding

Mr R: right, guys anyone else with another answer, force of attraction between two ions or sharing of electrons, but now i wanted the general definition, it’s just joining of two particles or joining two atoms to form a molecule that’s bonding, right, i remember first term we talked about bond energy, okay. Who can remind us of what bond energy is? Hands up guys, bond energy? Right can you give us?

Learner C: bond energy is the energy that is absorbed to break the bonds of the reactants and.

Mr R: to break the bonds of the reactants, energy needed to break the bonds of the reactants or you can define it as the energy that is released when a new bond is formed, energy absorbed when a bond is broken or energy released when a new bond is formed. Okay guys that bond energy that we have been talking about here is what we have been trying to explain here, in this reaction that we have here, these are joint together. They are bonded together, so the minimum energy needed to break these bonds is the bond energy of hydrogen, you see, so what is these substance must absorb a certain amount of energy in order to be broken into atoms and again this must absorb a certain amount of energy oxygen must absorb a certain amount of energy i order to break into atoms. Then after this has happened the re-joining of atoms will occur to form water, when water is formed energy is released. So the bond energ7y for the water molecule is the energy released when this bond is formed. And again it is equal to amount of energy needed to break this into hydrogen and oxygen. My next question is does the bond energy of hydrogen equal to the bond energy for oxygen?

Learners: No

Mr R: No, they are not the same because they are different substances and again the bond energy for hydrogen is not the same as the bond energy for oxygen, for water is not the same as oxygen and hydrogen, they are different because this is also a different substance. Right, they is a way in which to represent the bond between these two atoms, we use the cupper structure and sometimes we use the Lewis structure, but the most commonly use, that we are referring to is the cupper structure. And the for hydrogen it’s just (H-H) this means that they are two atoms that are shared between these two atoms, molecules they are two electrons that are shared between the two atoms. but for oxygen, do you remember it is a double bond (O=O) and then for nitrogen if you remember very well it’s a triple bond, here it means there are three pairs of electrons that are shared between these two atoms. Which of these three bonds do you think are the strongest?

Learners: The triple bond

Mr R: the triple bond, the strongest there is the triple bond as you include the number of bonds, the stronger the bond becomes and then there are some factors that we have spoken about....remember there are some other factors that we talked about which can increase or decrease the strength of the bond, what are those factors?

Learner D: The size of an atom, yes. The size of the atom, the stronger the atom the stronger the bond [...] it means the length between the two atoms will be smaller, so the smaller the length the stronger the bond [...] right. The other thing that we talk to in grade 10 is the type of reactions that I want us to focus on. One of them is this one (endothermic reaction), the other one is (exothermic reaction). Right, can you just define those two types of reactions? Endothermic, define what endothermic reaction is?

Learner S: change in the internal aspect of the substance, temperature

Mr R: temperature, okay. Anyone with another answer, endothermic reactions

Learners: [laughing]

Mr R: Learner F?

Learners: [laughing]

Mr R: ah what's your answer, okay Learners R?

Learner R: okay is the reaction were heat energy is being absorbed

Mr R: by the substances, is the type of reaction where by the system absorb what? Energy. Endo means into, so energy is taken into the system, those reactants absorb energy. So it means the energy is coming from where?

Learners: for the outside

Mr R: from the outside, the atmosphere neh and then exothermic reactions? Jah can you define it?

Learner: [....]

Mr R: so the heat is moving from the?

Learner A: inside to the outside

Mr R: so what is inside the container?

Learner A: heat

Mr R: Jah heat is there, from the inside to the outside but now what is fund in that container; let's say we are reacting that H with O"

Learner A: the reactants

Mr R: the reactants neh, so in other words the system, which is our reactants plus those products because they were together, now they release heat to the atmosphere to the environment. This is what we meet endothermic reaction is the type of reaction were the system, when we talking about the system is the contained, what is inside the container, so in that case the system is releasing the energy sorry. Endothermic reaction is were by the system absorbs the energy from the environment and then exothermic reaction is were by the system releases the energy into the environment, right, environment is the atmosphere. Sometimes the environment if you are holding that container, be your hands, so right. That's the thing. Right now what i want us to look at now is to write the equation of exothermic and endothermic reactions including that heat energy which we are talking about, right we want to write, let's say i take this equation now, i take this equation H2 plus N2 is equal to NH3, if this is exothermic reaction were do i put energy, let's say this exothermic reaction. Its exothermic reaction that's what it is. Right i want to include the word heat do i put it on the reactant side or the product side?

Learners: product

Mr R: product because it is product of the reaction, it's released, you understand? So am happy about that, so it's plus what, heat. So every time you see an equation like this where heat is on the product side it means it is exothermic reaction right, let me go to the processes of life that are common photosynthesis and respiration, which of the two there are endothermic?

Learners: what?

Mr R: respiration and photosynthesis?

Learners: respiration

Mr R: is what? Hands up?

Learner A: respiration

Mr R: respiration is endothermic, do you agree?

Learners: Yes

Mr R: right, why because we release heat energy which warms our body and keep the temperature constant during respiration. Where does that heat come from? The reaction of what? It comes from the reaction of what?

Learners: [laugh]

Mr R: i mean in respiration, we are saying the reaction is exothermic, it releases energy, so that energy [...] what are the raw materials for respiration?

Learners: carbon dioxide and oxygen

Mr R: carbon dioxide and oxygen? Raw materials, what are the reactants?

Learners: [...]

Mr R: for respiration, listen guys, i respiration is the process that happens in our cells and the aim of respiration is to release what?

Learners: carbon dioxide

Mr R: carbon dioxide? The aim of respiration?

Learners: [...]

Mr R: [....] in your body, do you use any CO2 do you use it?

Learners: No

Mr R: guys in the first place, because of that reaction CO2 won't be there, do you know that?

Learners: Yes

Mr R: yes, it occurs because of respiration, otherwise if respiration was not there, it wouldn't be there. So you can't say we respire to give out carbon dioxide, what for?

Learners: [laugh]

Mr R: quiet, can we proceed CO_2 is released during respiration as a by-product but there is a main product that is necessary for our body, what is it?

Learners: oxygen

Mr R: oxygen we take it in for respiration

Learners: Yes

Mr R: but i respiration occurs for what?

Learner A: for life

Mr R: oh for life?

Learner A: yes

Learners: [laugh]

Mr R: alright, guys you eat food every day, that food some of it is for building the cells so that you grow, but for that, to build the cell, there is energy needed [...] for you to [...] you see that, the enzymes will function the temperature must remain constant because if the chemical changes, remember enzymes are [...] right, so the heat that maintains the temperature comes from respiration, is the product of respiration. The energy that you are using for eating, walking, the heart to function, it all come from what? Respiration. Is released from the food through respiration. So the main thing that we need during respiration to release energy, otherwise the food that you eat can just stay there. w\so what are the purposes of the food, is to release energy so that all the processes that are taking place in your body can occur. So the main product of respiration is just energy and i carbon dioxide is the by product, something like you are cooking there your food, you can't say the smoke is what you are aiming for

Learners: [laugh]

Mr R: it's just the by product that goes to the atmosphere. All we want is that cooked food inside there, you understand. So CO_2 is like the smoke that goes up, i water vapour is the by product that goes up, although after getting out of your nose it is useful to other organisms

Learners: [laugh]

Mr R: right lets right the equation for respiration there, can we write the equation for respiration including that energy, so it's what. Can you give me the raw material for, what do i react

Learner C: oxygen

Mr R: is it oxygen? Okay yes, right O2 from the atmosphere plus what?

Learners: and nitrogen

Mr R: and nitrogen? Oxygen yes, oxygen must be there, it reacts with what? Food, guys, what type of food?

Learners: Carbs

Mr R: carbohydrates, what is the formula for carbohydrates

Learners: C6, H12O6

Mr R: right, this one is solid, what do we get there, you get energy as the main product plus carbon dioxide (CO2) plus water vapour (H2O) water vapour. If you see on a cold day in the window you can see some water vapour, which means they is water vapour coming out of the room, you mount or body into the atmosphere, all this are by products, they are not the main products. What we really need is energy, so that our body can operate, the parts of our body can what? Operate. You understand? This are just by products they are there accompanying that. Alright, and then let's go to respiration, ya?

Learner: [...]

Mr R: let me just, I'm almost there. Right ah, let's go to photosynthesis which is another common process of life. Is it endothermic or exothermic?

Learners: endo

Mr R: endo-?

Learners: -thermic

Mr R: endothermic neh, right that means the reactants absorb what?

Learners: energy

Mr R: so what are the reactants there for photosynthesis?

Learners: carbon dioxide

Mr R: carbon dioxide gas plus, H2O water from the soil, right this time in liquid form plus since you are saying its endo energy must be added plus energy where does the energy come from?

Learners: sun

Mr R: from the sun, right and what do we get there, O2 and what is the main product there you get oxygen gas and then?

Learners: Glucose

Mr R: glucose is a carbohydrate, so its opposite of respiration, this one is solid. Again you can see that when it's endothermic you have to add energy, and this energy breaks these into atoms first, so that there is rearrangement to form oxygen and carbohydrate. So now if questions comes from grade 11 and grade 12, and you see that there is energy, before on the reactants side its endothermic, if there is energy on the products side it's exothermic.

Mr R: and as a result the whole system becomes an endothermic reaction, because if you subtract, let's say we are adding and here we are subtracting, they will be more what is released than what is absorbed that is why the whole reaction becomes an endothermic reaction. Right so in the next lesson we are going to carry out an experiment whereby we try to determine whether a reaction is exothermic or endothermic, right? Eh there are some worksheets here that we are going to use (distributing the worksheets). Right listen; don't worry about the wrong spelling. Can i give you the instruction there, it says that; '*you have learnt that energy is involved in a chemical reaction*', right that change of energy is another chemical change; it's another change in the chemical reaction. Remember we started with chemical change. So you talked about the changes in the substances, so the other form of change in the chemical reaction is chemical change. So there is absorption and release of energy in the total energy transfer and so on. So those are changes that occur during a chemical reaction. They are saying '*some reactions are endothermic while others are'*...sorry it must be exothermic can you correct that. "*some are exothermic, you are asked to carry out a practical investigation to determine if the given pair of chemicals are exothermic or endothermic, the following apparatus are given to you to choose from*" right these are the apparatus, and then under number (a) there its written '*the following pairs of chemicals will be given to you for investigation, plan and design your investigation'* you see in this case there is no method which is given to you, so now you have that paper you go, you form your groups, on Thursday we are doing this practical, you form your groups and try to come up with a method that you are going to use to determine whether the reaction is endothermic or exothermic sing these apparatus. Write down your own method, how are you going to determine whether this is endothermic or exothermic using these apparatus, but now you concentrating on pair number 1, 2, 3, 4 and 5, pair number one are HCl and NaOH I'm going to provide that. Now from here you have to form your group, you discuss as a group, ukuthi (that) we are going to do this and this, we are going to draw our table this way and record our results this way and this way. So that when you come you just follow your plan and then you carry out your experiment and then you can interpret it and draw a conclusion from your interpretation. And then after that you will write an experiment report from aim up to application and this is practical work for term 3 marks. So we will use this as a portfolio mark or as a task for term 3. So we are going to do it on Thursday, so now you can take the notes. So here you have to say whether is endothermic, i will move around there, you say whether it's exothermic or endothermic, for these three equations that we have up. Let me just add another one, Right for example the equation can be given in the form of a value like that, instead of just saying energy, we have given the value of the energy.

Practical transcription for Mr Reason

00009 (Learners doing the experiment)

Learner A: Sir it is calcium chloride into sodium who now?

Learner B: Sulphuric acid

Learner A: Yes! Its sulphuric acid, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, measure. 31 so it's […]

Learner B: 81, 91 (holding the thermometer into the beaker with $CaCl_2 + H_2SO_4$)

Learner A: oh

Learner C: okay you can remove it ke (then)

Learner B: (removes the thermometer)

00010 (Learners doing the experiment)

Learner P: Tsentsa (Put)

Learner Q: (pouring sodium hydroxide granules into a test tube and measuring it), a e se fetle? (Is it there yet?)

Learner P: a e se fetle (It is not there yet), I shape so (beat it like this). E kenye (Put it), [holding the thermometer, and putting it into the NaOH granules)

Learner R: no but still guys masithena iyaphansi (when we turn, it goes down) [pointing at the test tube with a thermometer inside]

Learner S: siyabona ukuthi (We see that...)

Learner T: iku 4 (It's at 4)

Learner Q: efetlile? (Is it there yet?)

Learner T: ya efetlile (Jah it is there)

Learner T: Ngicela ukuyibamba (can I please hold it)

Learner P: Izokushisa (it will burn you), yoh phezukwephepha, Hambani ezinkini, (yoh, on top of a paper, go to the zinc)

Learner U: ca nitsa nitsheni ninodwa (When you get burnt, get burnt alone)

Learner T: we still going to pour inside here (Sisazothela la) [pointing into the test tube with NaOH]

Learner Q: [measuring HCl]

Learner P: Woh, who! (Enough, enough!)

Learner U: hafola idai deng (Half the this thing), bekaniphansi anginithembi (put it down I don't trust you)

Learner Q: uyatatazela (She is shaking)

Learner P: [Measuring HCl inside the test-tube by pouring it from its container]

Learner Q: wait o seke wa tshesa le tsoho la hao (wait do not burn your hand), fine.

Learner U: it's fine.

Learner P: yini I initial? (Whats the initial?)

Learner T: 18

Learner Q: a yi changi (it doesn't change)

Learner S: isikhathi calani (the time, start it)

Learner P: [mixing NaOH and HCl]

Learner Q: thela (pour)

Learners: Yoh (screaming)

Learner P: Mix [stirring the thermometer into the test tube with the solution of NaOH and HCl

Learner U: Eh kuyanuka (Eh it smells). This thing smells so awful

Learner Q: ushile Learner P (Did you get burnt learner P)

Learner P: Uzosha (you will get burnt)

Learner U: iyashisa (Holding the bottom of the test tube)

Learner P: it is exo- , no hesitation yi (its) exo [still stirring] can you please check the temperature

Learner S: nayi la (it is here) [pointing at the top of the thermometer]

Learner T: ende I la (Yes, it's here). It's above hundred and ten (>110). It's above one hundred and ten

Learner P: it's hundred and ten,

Learner T: I two minutes ayikapheli? (Isn't two minutes finished already?)

Learner S: ayikapheli (it's not finished), 36 seconds.

Learner U: stop!

Learner P: [stops stirring]

Learner Q: entse (take it out), ikuphi? (where is the thermometer reading?)

Learner S: iya decreaser (it is decreasing), it's a hundred and ten

Learner T: it maybe a hundred and six, so its *exothermic neh*?

Learner R: yes

Learner U: whats the difference guys 106-18

Learner R: 92

Learner U: 92?

Learner R: 88

Learner U: 106

Learner R: 88!

Learner results in Table form: (06:03)

Chemicals	Exo/endo	IT	UT	Time	Diff
Hydrochloric acid & sodium hydroxide	Exothermic	18	106	2 min	88
Ammonium nitrate & water	endothermic	18	-1	2min	17
Sodium hydroxide & sulphuric acid		18		2min	
Calcium chloride and water	endothermic	18	14	2min	4
Sodium hydroxide & calcium chloride		18		2min	

Learners method: (06:09)

- With every test tube and chemical pour 4 ml of each chemical investigated
- Measure the temperature of the two mixed chemicals
- Observe whether the reaction of the chemicals combined is an exothermic or endothermic reaction.

00011

Learner G: Sodium hydroxide

Learner H: kwanuka amaqanda la kuhambani? (I smell eggs here what happening?)

Learner K: yi lento le (it's this thing) [pointing inside the test tube]

Learner H: This is the last one, sesicedile sishoda ngama recordings kuphela (we ae finished, we are left with the recordings only)

Learner L: nawa ama recordings (here are the recordings)

Learner K: sibala phansi ukuthi be siyenzani (we writing down what we were doing)

Learner H: sisebenzisa le ini, le ncwadi leya? (what are we using this book?)

Learner K: sisebenzisa (we use it) as the whole experiment, it is exactly what we are doing

Learner G: we don't have all of these stuffs

Learner K: it's exactly what we are doing, the conclusion will be the same, the method is the same.

00012

Learner A: okay […] neh [pouring sodium hydroxide into a test tube]

Learner B: tsamaya o rinser (go rinse), ah Learner C

Learner C: [ignores learner B] [proceeds to pour calcium carbonate into the other test tube]

Learner A: [mixing the two solids, NaOH and $CaCO_2$ and putting a thermometer]

Learner C: ayi dissolve mus (it does not dissolve mus0

Learner D: kuyafana kumele siyenze (either way we have to do it)

Mr R: here yi solid, iyeke injalo (it's a solid leave it like that)

Learner D: bathi iyeke injalo (they say leave it like that), iyashisa? (is it hot?)

Learner B: Yes, it's above room temperature 21 [looking at the thermometer]

00005 #2

Learner V: a re semole ka ye calcium chloride and water (let's start with this one calcium chloride and water). I was just saying that we should start with the things that we have.

*

Learner V: re semola ka sulphuric acid and water (we start with sulphuric acid and water)

Learner U: ke tlo tsela kafa akere? (Am I pouring in here isn't it?)

Learner W: No, you dilute both and then you gonna mix them

Learner X: u diluter ka de millimetres? (Do you dilute with the milimeters?)

Learner Z: iye tse 10 (make it 10), di tlo yetsang? (whats going to happen?)

Learner U: observe

Learner U: (sodium hydroxide e kafa?) is sodium hydroxide in this beaker?

*

Learner X: Ke ten? (is it 10?), ke tsele? (must I pour?)

Learners: Yes

Learner X: [pouring sodium hydroxide into water to dilute it and stirring it]

Learner V: [putting the thermometer into the sulphuric acid solution diluted in water] itsamaya KO 60 (it's going around 60)

Learner: after ho etsahalang? (After whats happening?)

Learner Z: (ntho yankga) this thing smells

Learner U: whats that smells?

Learner V: eya tshisa (it's hot) [putting his finger onto the beaker with H_2SO_4], and then we start mixing?

Learner U: e kenye messing (put it inside water)

Learner V: no I tse I drop (it must drop first0 [referring to the temperature of the thermometer]. Okay room temperature wa etse ke bo kae?

Mr R: okay what are you measuring there?

Learner U: atmospheric temperature

Learner V: we waiting for it to drop

Mr R: do you need it?

Learner U: Yes

Mr R: why?

Learner X: because it's too far

Learner V: because it […]

Mr R: what temperature, are you measuring the temperature, are you finding if it's endothermic or exothermic?

Learner V: No!, because it was high, if it measure high it was gonna give us, wan tla loganya (do you get me)

Mr R: its initial temperature in a substance?

Learner V: Sir, it was high, so we are waiting for it to drop

Mr R: it can't be zero

Learner V: it was high ne re e tswere (besiyibambile). E ko 35 neh (it's at 35). E ko 35 guys a e so tlole e droper (it's at 35 it's no longer dropping). Okay, so what do we do we mix them together? A ra tlakansa nah? (are we mixing?)

Learner X: re tlakansa eng? (What are we mixing?)

Learner V: e le e (this one and this one) [pointing at H_2SO_4 and NaOH]

Learner W: we mix, sulphuric acid and sodium hydroxide together and then you wait for the reaction

Learner X: [mixing the two solutions]

Learner V: wena tswara nako (look at the time)

Learners: Who

Learner U: yey satsha (getting burnt)

Learner V: [putting the thermometer into the mixed solution]

Learner U: ena ke exothermic reaction (this one is exothermic reaction)

Learner V: 7,2

00004 (#1)

Mr R: […] what you prepared, if you haven't done that, can you do it now. Prepare it and you gonna do that experiment now, write, how I you going to do that. You can use books, finds some methods in those books, see how it works…alright guys when you are given an instruction may you do that coz now you delay us. Right after preparing your methods there, you come and take your apparatus, what you will need.

Learner U: de test tube ke tsena (there are the test tubes)

Learner X: de teng (they are here). Ke wo method (here is the method) a les is there (everything is there) [pointing into the text book]

Learner: sodium hydroxide, potassium hydroxide...deteng di lo tse (this things are there)

Learner W: all of them

Mr R: take note of what you have in that book

Learners: Yes

*

Learner A: I'm gonna try this

Learner B: we gonna try it. So basically [….] which is acid […] hydroxide, we have there and then […] a metal, something metallic.

Learner A: you do realise that for now we just need the method right now and then we will conduct the experiment later after we have the method?

Learner B: Jah […]

*

Learner D: asenze u method, sizokhonaukubona into esiyenzayo (let's do the method so that we know what we are doing).

Learner C: [reading the textbook] bathi dissolve about, angazieyani […]. Ah mus okay thinasizothi (we will say) dissolve about 1 of each of the following substances, beseangithi sisebenzisa, okay le ikhona neh (okay it is here) calcium nayi (here)

Learner B: nasi is calcium chloride (here is calcium chloride0 [pointing at the textbook]

Learner C: okay Jah, sisebenzisa zona futhi (we are using them again) kune (there is) calcium chloride, nayi (besiyibhala). Okay

Learner A: angithi yi sodium hydro oxide

Learner B: aha (No), asi.., ke yone (its it)

Learner E: ammonium ke NH (ammonium is NH)

Learner B: ke NH? (its NH)

Learner E: ke NH4 (it's NH4)

Learner D: yi sodium le

Learner E: I sodium hydroxide?

Learner D: nayi (here) soyenzangamanzithina (we going to do it with water) neh calcium chloride (and calcium chloride). Okay ke soyenzange calcium chloride (okay we going to do it with calcium chloride), kusho ukuthi (that means) lenaangkesiyimixenamanzi I out (we will not mix it with water, its out), angithisimixer neh lo or sisazoyimixernamanzi (we mix it with.. or we mix it with water). Sozimixerzi two besesifakanamanzi? (we mix both then add water?)

Learner A: just follow, agithi bathi lana (here they say) we just have to react sodium […] lana is […]

Mr R: Eh what we are aiming to do there, how are you going to, I can see that you have picked up this one (thermometer). How are you going to use this?

Learner E: measure the temperature

Learner D: Sir to investigate whether the reaction is exothermic or endothermic

Mr R: okay, so when do you measure?

Learner D: hao basicedauku mixer (when we are done mixing), for example masicedaukumixer hydrochloride acid neh sodium hydroxide (for example when we are mixing HCl with NaOH) then sizo (we) measurer I temperature.

Mr R: then what do expect to see?

Learner D: if I high, then its exothermic, if I high yini? If its high its exothermic, if its high what is it?)

Mr R: Guys, this thing if you look at its indicating certain readings, what is the reading of this?

Learner D: its room temperature

Mr R: Its room temperature, so do you think when you put, immediately you fix this, will the temperature be high or the same as the room temperature? Immediately you mix the, your chemicals, will you get a higher temperature or the same temperature as this one?

Learner A: if it's an exothermic, I exothermic iya releaser? If it's an endothermic Sir, I think its izofana neh room temperature (I think it's going to be the same as the room temperature) and if it's an exothermic then I temperature izo increaser (then the temperature will increase)

Learner B: I think it's the other way around

Learner C: don't you measure the temperature first, so we know?

Mr R: Guys, guys order, order, can we have her suggestion

Learner C: I was saying don’t you measure the room temperature first and from that room temperature we know it’s either gonna increase or decrease? The temperature of that things we gonna mix?

Mr R: Guys, guys, I think she’s go a...

Learner B: she has got a point

Mr R: Yes, you can’t expect to mix the things and then you have high temperature at that moment. You must expect to have the same temperature as the room temperature, because every substance has a room temperature. Then if it’s exothermic, we expect it to do what?

Learner A: increase

Mr R: to increase?

Learner B: to decrease

Mr R: able to decrease neh

Learner A: or the temperature or the substance?

Mr R: I don’t know, you will conclude yourself. So now what I want you to, listen guys, what I want you to be clear about is that you measure the temperature, the initial temperature and then after maybe a certain time, you measure the what?

Learner C: the final

Mr R: then you conclude, you can’t say immedietly you put its exothermic or endothermic.

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Learner H: Mr R?

Mr R: like the question is saying, you are investigating a substance is exothermic or exothermic. Right listern, learner H. guys can I ask you a question […] you have to come up with your own method. You must come up with your own method neh, what are you going to use in order to determine whether the reaction is exothermic or endothermic, what are you going to use?

Learner J: we use a thermometer

Mr R: a thermometer

Learner J: Yes

Mr R: right, how are you going to find out whether its exothermic or endothermic?

Learner J: with the temperature sir, as I said when the temperature increase its going to be an exothermic reaction heat is out, so when its endothermic I think the heat of the thermometer is will drop, because its ..

Mr R: now how can you, what measurements are you supposed to take to find out whether the temperature has increased or decreased?

Learner J: we are going to take room temperature and then, its room temperature and, it room temperature and what sir?

Mr R: temperature of what?

Learner J: the thermometer and the, kopa ho checker (can I please check)

Learner G: […] the reaction?

Mr R: […] jah the answer is somewhere there, but now I want to be clear of whether when do you take the temperatures? The temperature it will be the temperature of the what? The substance and you just the temperature of the air?

Learner J: measure for our reagents we going to make

Learner G: isn't it you temperature of the air? […] area around, if its exothermic, its endothermic we measure the substances themselves or what?

Mr R: [laughs]

Learner J: […] so I think before the reaction we are going to measure for the reaction

Mr R: when exactly? So you mean to say I could one substance here

Learner J: one substance and we are going to test

Learner G: can it be while the reaction is taking place, while its taking place and then after, coz while its taking place if its endothermic it needs heat to react that's when we take it, and then after it has reacted, I don't know sir, im asking

Mr R: im not clear, what you are saying is not clear to me, mina I know what suppose to..

Learner B: mamela bathi kuwe (they are saying to you) before if its exothermic, they take the temperature of the substance

Mr R: when?

Learner B: before..

Learner J: no sir, let me tell you, for example this is sulphuric acid

Mr R: let's take these two substances there, ah these which are first ones

Learner J: uhm, hydrochloric acid and sodium hydroxide, first the thermometer before doing anything its at room temperature akere (isn't it)

Mr R: and that thermometer is just ther neh, you said you are measuring what?

Learner J: jah, the temperature according to the room temperature

Mr R: temperature of what?

Learner J: of room temperature

Mr R: if the thermometer is like this, it is measuring the temperature of the air, so this is what you are measuring

Learner B: No, sir kusho ukuthi (it means that) the substance […]

Mr R: […]

Learners: that's what we were saying

Mr R: no you were saying..

Learners: No!

Learner B: to find out whether its endothermic or exothermic, we measure before and after

Mr R: alright, so you said before, it when you are mixing?

Learner J: yeah

Mr R: right and then after when is the after?

Learner J: after the reaction

Learner B: after the reaction

Mr R: […]

Learner J: we will wait for it

Mr R: for how long?

Learner B: as long as it reacts

Mr R: fix time, that would be better, to fix time. Let's say maybe after 5 minutes, 10 minutes or so.

WP_20150903_004

Learner A: calcium chloride e kae? (Where is calcium chloride?)

Learner B: guys a rena calcium chloride (guys we don’t have calcium chloride)

Learner C: ke e eteng, ke nyane (here it is, it’s too small), ba etse sodium chloride (they said sodium chloride)

*

Learner A: okay lets move guys

Learner D: re etsa eng (what are we doing)

Learner A: number 3

Learner E: we can’t go on without…

Learner F: ikhuphukile? (did it go out?), yakhuphuka (is it going up)

Learner D: e ya (Yes)

Learner G: beyehlile, yakhuphukile futhi (it was going down, now it is increasing)

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Learner W: do you realise ukuthi asinawo ama chemical la (do you realise that we don’t have chemicals here)

Learner V: azobakhona (we will)

Learner W: Wo (Okay), akingane neh (they must be equal). Asichecki (we don’t check) I room temperature we are reading from here. Sithatha I (we take the thermometer) themomter neh and then whilst we mixing the chemicals together, angithi obviously angithi if it’s an endothermic whatever ezoyenzeka izokhuphuka (obviously if it’s endothermic, whatever happens it will go up). So sizosenbenzisa I thermometer uku mixer (we will use the thermometer to mix, whilst we pouring water) whilst we pouring water, so that if I reaction ikhipha umlilo, then sizobona nge thermometer (they if it releases heat we will see through the thermometer). So asinandaba ne room temperature (we don’t care about the room temperature)

Learner U: ehe all im saying is kwamele sazi I room temperature (All im saying is that we have to know the room temperature) in order for us ukuwazi (know) […]

Learner V: Jah (yes)

Learner W: angithi sesiyazi ukuthi yi 21 (we know that is 21), oh so mayi decreaser (so when it decreases) re tlo tseba gore keng, kana ke feng (we will know what it is, which was is it) ke endothermic and then when it increases its exo.

*

Learner V: okay ku (in) method so far I only got 3 pointers, for every test tube and chemical pour 4 ml of each chemical investigated, if that makes sense. So you guys can give another suggestion. And then ngathi measure the temperature of the two mixed chemicals, and then I said; observe the reaction of the chemicals combined is an exothermic or endothermic reaction, which is when you measure nge (with a) thermometer. But I only got there pointers, so angazi if ungakhona ukuungibhalela yona kahle so that you can all understand it (I don't know whether you can write it for me so that you can all understand it). Coz I just wrote I draft

*

Learner W: you didn't say wheth er it makes sense?

Learner Z: what's making sense?

Learner W: method

Learner Z: I think we must have a method for each

Learner W: No, I think we must just give one method for everything.

*

Learner W: Sir, ngicela uze la? (Sir, can you please come here?), ngicela ukuku spelle I method yethu? (can I spell our method to you?)

Mr R: okay

Learner W: sithe (we said) every test tube you must pour 4 ml of the chemicals

Mr R: okay

Learner W: and then after that we said we gonna, measure or record temperature that is given off air after stirring

Mr R: before you mix?

Learner W: before we mix…

Mr R: okay

Learner W: …and after

Mr R: after it must be after some time

Leaner V: mmh (No)

Learner W: after, not same time

Mr R: mhm

Learner W: so do we measure before, when we mix without stirring or after mawuceda uku stirrer (or after stirring)?

Mr R: you must record the initial temperature and final temperature, so […], that other substance will be having the same temperature as this one. Ungaze uwa mixe (you can even mix them), uwa mixer at the same time

Learner W: how […] kwi ammonium nitrate

Mr R: into engiyishoko (what im saying) unga measure I ammonium nitrate, I temperature yamanzi iyafana ne ammonium nitrate (the temperature for water is the same as that of ammonium nitrate) ngoba wonke a phuma […]

Learner W: Sir, so ingathi masiceda ukuzi mixer (when we are done mixing them)

Mr R: nansi ibhalwe la (here its written), nansi I bucket has got water, I bucket has got […] the temperatures here are the same. So the same, unga measure lapha its initial kuyafana nale (so you can measure here its initial it's the same as this one). So mangizimixer (when I mix them) it's the initial temperature, you understand. So from there kumele wenzeni (what must you do), you wait for some time, for the reaction to occur, then you measure the final temperature, maybe 10 minutes and of course it could be longer. So you record that.

Learner W: […]

Mr R: so iyafana nale (it's the same as this one), so there no need for you to measure

Learner W: one, one

Mr R: One, one.

Learner W: wo, so size measure masezihlangene (so we must measure them combined) before sizozi ngoqcoza na after? (before we sitr and after?)

Mr R: its up to you ngoba noma uyi measure kanje, iyafana noma usadukuzi hlanganisa (if you measure it like this, it's the same as when you just mixed them)

Learner W: iyafana? (the same?)

Mr R: Ehe (Yes), so kuqcono mani measure before and then su fixer I time yakho ukuthi… (So it's better you measure then fix your time so that…)

Learner W: in 5 minutes or in two

Mr R: I two minutes ayisiyicane kakhule? (Isn't two minutes too small?)

Learner V: 3, 4?

Mr R: enza ni isikhathi (make time) […], isikhathi silingane for all ama reaction, maybe 5 minutes, 5 minutes

Introduction for Kush

Mr K: right guy um, you are going to look at um, we are going to look at aspects around energy changes and chemical change, so perhaps we need to understand the terms in that phrase ‘energy’ and ‘chemical change’, what is energy? Right. What do you understand by the term energy and what do you understand by the term chemical change? Okay. Now can someone tell us? From your own knowledge from what you have done what energy means to you? What do you understand by the term energy?

Learner A: Ability to do work

Mr K: ability to do work right? I think that is the simplest definition that we have been using from grade 9, and then chemical change, chemical change, what does it entail? What is a chemical change? There are two things energy and chemical change; we are relating energy and chemical change, what is chemical change? Yes Learner B?

Learner B: I think it’s when they is breaking and formation of bonds

Mr K: It is when they is breaking and formation of bonds, okay, good... Anyone with a different answer? Different way of understanding? A chemical change, what is a chemical change? Yes?

Learner C: it is the formation of bonds

Mr K: it involves formation of bonds, okay, good

Mr K: anyone with a different answer, chemical change, yes? I see you want to say something

Learner D: I think that temperature is. When it changes it starts as something but when the [............] like what in the beginning of the reaction. It becomes a different compound or molecule.

Mr K: okay, good. So all in all i think you have said it right, in chemical change you end up with a new substance right, a formation of a new substance, you start with substance A and then you get substance B. It is different from a physical change right. Because you can also have a physical change were perhaps, you have a substance like water right, you have it in a solid state right as ice, you heat the water, it changes into what? Into liquid, is that a new substance?

Learner D: No

Mr K: it’s not, it’s still the same, if A solid, A liquid, you continue to heat it, it becomes what? A gas. So it A throughout, okay, so what we are actually doing, in that case. We changing the state not the substance. But in chemical change, we start with a one substance and that substance will change or give you a completely new substance, right. I will just give a simple example to find.illustrate what we talking about in chemical change if you have for instance H2 reacting with Oxygen, okay. What is the obvious product here?

Learners: (chorusing) H2O

Mr K: its H2O right, so you are going to have H there the 2 as you said and then that, so you hydrogen reacting with oxygen to form what, water H2O right and I have used a red colour to represent hydrogen and a black one to represent oxygen. Now when you deal with this you must always balance, because the Stoichiometry of the equation is very important, right okay. So from this side we have two atoms, so let me ask, how many atoms of hydrogen do you have/

Learners: Two...

Mr K: How many molecules do you have?

Learners: One

Mr K: one because oxygen and hydrogen exists as diatoms, right they are diatomic, now, let's try to balance we have two of these and two of these. So the hydrogen is balanced, oxygen we have two and this side we have?

Learners: One

Mr K: what do you need to do?

Learners: need to put a two

Mr K: need to put a two right. A co-efficiate, you don't have to put a two here, okay you are aware of that. So incidentally here our hydrogen become 4, which means that you must also balance this side, so here we must have our/

Learners: two

Mr K: and very important you must also have state symbols, okay. We must have also state symbols to show the state at which the reactants and products are in right, if they are all gases then you must have that g is gas. But in most cases these ones (H2 and O2) are at room temperature right and what is a liquid at room temperature, but you can have water as a gas as well, okay. Right if is heated. So now in this reaction, it involves what we call energy change, right okay. In any reaction there is always an energy change and that energy change we use it to classify a reaction, whether is endothermic or exothermic, depending on the energy change, okay. Now if you were to take, perhaps if I were to redraw this, okay. As i asked earlier on, how many molecules of hydrogen do we have here?

Learners: two

Mr K: we have two right, and how many atoms do you have? How many atoms

Learners: four

Mr K: four, one, two, three, four, there are four atoms and two molecules. Lest go to oxygen here, how many molecules of oxygen do you have?

Learners: two

Mr K: okay, and we know that these are called valence bonded bonds from what we did in first term right, this is the copper structure (O=O), when we use lines or the copper notation, good. Now let's go to the product side, we have two of those (2H2O), we have oxygen, all of them bonded to, or before we go to talk about that right, let's talk about (o-o) and then we have (h=h) and we say they are four of them right, okay and then we will have the oxygen there and then our hydrogen's, okay. Now in this side we have out reactants, right. In any reactions we need to have reactants and end with what?

Learners: products

Mr K: so our reactants are hydrogen, oxygen and then are transformed or changed into what? Into water, okay. But now what should happen to this molecule, what should happen

Learner E: they must break, sir

Mr K: These atoms must separate, they must break now. In order for them to separate what must happen in terms of energy, let's raise out hands. In terms of energy learner L, what must happen?

Learner L: energy must be absorbed

Mr K: Energy must be absorbed, good, so here will have bond breaking, right and as she rightly said energy must be

Learners: absorbed

Mr K; so here we have energy absorbed. And now on the other side, or the other hand, we now have bond formation; new bonds are formed, what should happen here? It must be?

Learners: energy must be released

Mr K: Energy must be released, good, so we have energy released right, good. So we have bond breaking here, were it takes in energy and we have bond formation which actually releases what?

Learners: Energy

Mr K: Energy, now before we get to the new bonds, before new bonds are formed right, the atoms must actually what? Separate right. When bonds are broken atoms separate. When they are freely then they can start to rearrange, they arrange with other atoms so that they can form new bonds, okay and in the process of forming new bonds, energy is what? Is released, okay, now it is that energy or the difference in energy of the products and the reactants that will help us classify as either is endothermic or exothermic, now take note we are talking about the net energy, the overall energy change that the overall energy change. Is not necessarily that the energy that was absorbed here? Okay it is important for you to understand when we talk about the two processes of endothermic and exothermic you always have energy absorbed and energy released. Bond breaking is what we called endothermic process, right. Bond breaking is an endothermic process. Whereas bond formation is an exothermic process, right. Now let's go to the energy diagram, I think from the energy diagram it will make more sense, uhm if you have. Right this is our reaction formcus, you do this and then you go there i will just put some values here, let's put 10, here 5 and then here its 2. Again here we have 10, and this is uhm lets say 2 and 5, right. And on our axis here we have reaction cost and here we have potential energy which is kj/mol and in here we have kilojoules per mol, okay. Now lest look at this, as I have said here, there is always an energy change and that energy change which is actually heat change, because energy exists in different forms right. But here we are interested in the change in what? In heat energy per ser, now if this one are the reactants, you have your reactants here, like in that case our reactants were hydrogen and oxygen and our product in that case was water, so you have reactants and then products like that right, now for you to classify as i said the energy change in heat which is normally represented by delta H, okay so delta H, what is the meaning of delta H? What does delta H represent?

Learners: Enthalpy

Mr K: that's the enthalpy change, in other words the symbol H simply means what?

Learners: Enthalpy

Mr K: enthalpy right, H means enthalpy. But where there is delta it means there is change, that's an enthalpy change, which is sometime called the heat of reaction. The enthalpy change is actually given by the enthalpy of the products minus the enthalpy of the reactants. That's the formula which you use to calculate the enthalpy change (<H=Hp-Hr). Now for the two energy diagrams that I have drawn here, can you calculate the enthalpy changes? What is the enthalpy change here in the first reaction?

Learners: [Talking]

Mr K: Let's have one person, yes learner M?

Learner M: 2-5

Mr K: 2-5, which will give you what?

Learner M: -3

Mr k: -3 right, very important, so here you going to have, let's say delta h is going to be 2 minus 5 to give us -3 kilojoules per mol, now what does that tell you? It means that it is an exothermic reaction, why? Because delta H is less than zero. So any value less than zero, the reaction is what? Exothermic. It means this one is an exothermic type of reaction, so that exothermic, let's go to this one, right using the same formula you can also find the delta h, the change in what? Enthalpy or enthalpy change, okay. For this one Learner f, how do you calculate the enthalpy change? How do you get the enthalpy change for this particular energy diagram? Learner K can you help here? Learner C? Because these one are your products enthalpy of the your products and your enthalpy of the reactants is 2, so that's going to be delta H 5 minus 2 to give you what?

Learners: 3

Mr K: which is actually positive, positive 3 kj/mol, okay. So I'm emphasizing the negative and the positive, why? Because that's were you get the idea of endo and exothermic, okay, so now this becomes your

Learners: endo

Mr K: the endothermic reaction, right, that's the endothermic reaction, because your delta H is greater than zero. Which means that it is a positive value, so, through substitution you get a positive value, it means that particular reaction is endothermic reaction, okay good. The values that you read on the y axis here are the enthalpies of the what? Of the reactants and products, right. Now by the enthalpy we are actually referring to the internal energy right, that's the internal energy, the internal energy of the reactants and the internal energy of the what? The products. This is what they have, but now when the reaction is taking place, we are saying in order for the reaction to take place, this reaction according to the diagram must move from 2 to 10 neh, and what is happening during process, when you are moving from 2 to 10 here what will happen, it terms of energy

Learners: [chorusing...]

Mr K: energy is absorbed, so there is energy absorbed, so if i were to ask, how much energy was absorbed in this case?

Learners: [......]

Mr K: right, so moving from two to ten, eight kilo joules was taken in or absorbed, and where has the 8 kJ gone? What is 8 kJ used for

Learners: to break the bond

Mr K: to break the bonds, so energy is absorbed during bond breaking, so the 8kj taken in or absorbed is used for bond breaking, that's why in this diagram you have this part which is showing you that it is absorbed, right. Now we get to that point that we will talk about later, now we move from 10 dropping to 5, okay, what is happening during that process?

Learners: Energy is released

Mr K: energy is released, why is energy released?

Learners: because of bond formation

Mr K: so bond formation involves release of energy, so very important as you are moving up the energy diagram, energy is absorbed or taken in, okay, and as you are moving down energy is what? Is released, so i normally what to call this one an endothermic process, (up) this is an endothermic process and (pointing down) this is an exothermic process. I'm not saying this is an endothermic reactions and exothermic reactions, I'm saying process, when you are talking about a process I'm saying during that stage, the energy is what? Is taken in, because the term endo simply means taken in and the term exo simply means taken out. Is an endothermic process (pointing to down) and this one is what (pointing to down) exothermic process. If you go to this graph, same ting applies, this is an endothermic process and this is an endothermic process, right. But now the overall picture that you get in terms of energy absorbed and energy released is what you use you classify endothermic and exothermic reaction, right. Okay, but they is always energy absorbed and released in both exothermic and endothermic reactions, right. I'm trying to gather the notions that if you have endothermic you can say that it is a reaction that involves the absorption of energy, and they is a possibility that...as you can see on that diagram, this is release of energy from 10 going to 5, how much energy was released there?

Learners: 5

Mr K: 5 kj, but we are talking about an endothermic reaction, so it does not mean that when a reaction is endothermic, there is only energy absorbed there is also energy released and also when you talk about exothermic reaction it does not mean that there is only energy released there is also energy absorbed during bond breaking, okay, but now it is a question of how much as i said earlier on how much energy was absorbed and how much energy was released. For this reaction if i were to ask, how much energy was absorbed, how much energy was absorbed?

Learners: 5

Mr K: Let me just write, okay, you saying its 5. Right, then released? Released is how much

Learners: 8

Mr K: so you have 8 kilo joules and here you have 5 kilo joules, now let's compare which one is greater energy absorbed or energy released?

Learners: Energy released

Mr K: that's why we are saying it's what?

Learners: exothermic

Mr K: so now when now we define an exothermic reaction, you say it the reaction were energy is released?

Learners: Nooo

Mr K: what do you say? Let's have one person, yeah Learner D?

Learner D: it's a chemical reaction were energy, there is more energy released than absorbed

Mr K: Excellent! It's a chemical reaction were more energy is released than absorbed, okay. We are now giving an account of how much was taken in and how much was released. Coming to this one, doing the same thing. How much was absorbed here?

Learners: 8

Mr K: 8, how much was released? Is it?

Learners: 5

Mr K: its 5 right, okay. So its 5 kilo joules, right. Now take note which one is greater?

Learners: Absorbed

Mr K: Energy absorbed and here

Learners: released

Mr K: energy released, right, so now there is more energy absorbed than released and that tells you that it is an?

Learners: Endothermic, so it is actually the net energy, we are interested in the net, the net is the one used to classify the reaction. Now here in terms of the net, find the difference here? 8 – 5 is going to give you how much? It gives you how much?

Learners: 3

Mr K: it is going to give you positive 3 right, it okay, okay, if you want to say, I'm not using this formula, I'm jus trying to give an account of the net energy released it terms of magnitude, not necessarily plus or minus, so the magnitude here it means that they is 3 more kilo joules that will be released, we are talking now the net, so 3 more kj were lost that's why we are calling this one an exothermic reaction and also in terms of the net this is going to be 8 – 5, we are going to have 3 more kj, so the net is what you us to classify the reaction exothermic or endothermic, okay, is that clear? Now it's very important for you to understand that for you the important thing that you must take note of here right. We also have from this point where we have reactants to that point okay, this area that we have been talking about which is the energy absorbed, in this case which is 5 kj right, what is this energy needed for? Can you attach a name what name is give to this energy, the 5 kilo joules, what name is given to that energy, yes Learner T?

Learner T: Activation energy

Mr K: Activation energy, good, in other words activation for this reaction was 5 kilo joules. And what is activation energy, how is it defined? What is activation energy? Learner G?

Learner G: amount of energy needed [........]

Mr K: the amount of energy need to start a chemical reaction, okay, anyone with a different or you want to add something to that definition?

Learner Y: minimum amount

Mr K: minimum amount okay, okay so the minimum needed for a reaction to what?

Learners: to start

Mr K: to start, okay, what it means is that with that minimum the 5 kilo joules the reaction cannot start, so anything less than this will not start that particular reaction so you need to invest 5 kj so that it can what, it can begin. For instance if they were 4 kJ it means that the reaction was not going to start, so it's actually the minimum, it can be more right and then the reaction can what? Can proceed. It very important for you to understand that a reaction, or most reactions needs activation energy, okay. We also have this section here which is our delta H so this is the delta H or is actually the net that we use to identify whether a reaction is endothermic or exothermic, which is the three that we were talking about 5 minus 2,the minus 3 right. Okay, on the other hand we have this from here up to this point as you said the overall energy released. Okay, so if i were to look at this reaction as a reverse reaction, what will be the activation energy? If we were to look at the same reaction as a reverse meaning that these ones become our reactants and these ones become our?

Learners: products

Mr K: what will be the activation energy [....] its becomes [....] everything changes, it means that you need to [...] so it will be 10- 2, so your new activation energy will be 8, okay, good. So let me let you understand it in two ways, coz a reaction can be you can talk about the forward and the reverse, especially when the reaction is reversible, right but you know normally when your reaction is reversible you use these (reverse reaction arrows), the double arrows show you that the reaction can either go forward or backward. But if they is a single arrow it only shows that the reaction can only go forward not backward, so if there are two arrows there it means it can go in any way. Now for argument sake, the forward reaction here we said is what, what is the value of the [...]? It is?

Learners: [...]

Mr K: Negative 3 rights, then for the reverse reaction, it becomes

Learners: 3

Mr K: it's how much [...], it is very important the positive and the negative, you see [...] it will depend on where the reaction is going, right. So the positive the negative, will tell you like in this instance, the forward reaction is -3 and the forward i plus 3, so it very important for you to put is sign to tell us whether the reaction is reversible, which values you are looking at. Okay now we can also have some reactions were a catalyst can be introduced, we can introduce a catalyst, now the effect of a catalyst is to speed up the reaction, right, a catalyst speeds up a chemical reaction, catalysts exist in two forms one that are called organic catalyst and inorganic catalysts. Organic catalysts are ‘living’ perhaps catalysts, for the term itself right organic, these are from living material right and enzymes are actually good examples of organic catalyst, enzymes we find them, where do we find enzymes? In our stomach neh? In our stomach that were find enzymes and plants also have, right, okay. Uhm, enzymes are there to speed up the rate at which digestion takes place in our bodies’ right? Okay and now in this case, most cases in industries they use inorganic catalyst, right. Inorganic catalyst it means that the catalysts might be made from metals [..] platinum, they use as catalyst for reactions, right, perhaps for industry to produce more yield, right or to produce more products because in industries, they are interested in making profit right, so they cannot carry out a reaction that can take two years for them to get a product it does not make any economic sense, because they need to pay the electricity, electric bills, they have to pay the workers, so they need to get money as quickly as possible. So in order for them to get the produce or in order for them to produce in the shortest time as possible, they use a catalyst, they catalyst helps in that they get whatever they want in the shortest period of time and then they pay the bill and [...] and perhaps make profit, that the person of industry anyway. You cannot run a business that does not make profit, okay. So catalyst are used to speed up the reaction, so how do they do that by reducing the activation energy, okay. So if the activation energy was very high, with introduction of a catalyst i will be able to lower that activation energy, right. Okay, a catalyst will choose n alternative route that uses less activation energy, that’s very important. Instead of climbing this big hill it’s going to climb a smaller hill, so the introduction of a catalyst [...] it is very important to understand the role of a catalyst in chemical reactions. So catalysts are very important in chemical reactions, because they perhaps if its energy, they can actually save energy. Uhm instant of using the 8 kJ, perhaps to about let’s say 8. Okay, so that very important for you to what to understand. But now they is one concept that i think you should actually look at, okay. You are talking about energy what? Changes right. In a reaction, it is very important to note that when energy changes temperature also changes. Okay, were there is change in energy, temperature also changes, so now i just gave an example it is not related to [..] if someone was to open the door, someone opens the door, i think i will ask learner D, co she is closer to the door, what are you going to feel?

Learner D: [...]

Mr K: or you want us to open that door, tell us the feeling, cos i felt it when someone opened. The door when someone opens the door there, you will feel a bit?

Learner D: warmer

Learners: [(disagreeing, ahhhhhh]

Mr K: it seems like everyone disagrees

[Audio unclear....]

Mr K: [...] i know but today it seems like it’s a bit cold, if someone opens the door, you will feel a bit cold. I feel cold, when someone opens...okay its fine, looking, it’s sunny today

Learners: [laugh]

Mr K; the experience is that even me i left my jersey, i though today was going to be warmer, now i feel like it's a bit chilly. But now what exactly happens why do you feel cold, when someone opens the door, how do you explain that? What happens, you are sitting there all of a sudden the door opens and you feel chilly, why, why does it, how do you explain it in terms of science, what's the science and you are also Geographic's right?

Learners: yes

Mr K: okay then tell us she is one of them? How do you explain it, you open the door is it the cold air coming in?

Learners: [yesss] [Nooo]

Mr K: is it hot air coming in?

Learners: yes

Mr K: its wind coming in, okay, ah it's actually the opposite right, it's the opposite, it's actually warm air coming out, ye. That's why i said geographers, what happens when air is warmer what happens to it? Does it subside? It rises neh?

Learners: Yes

Mr K: yes warm air rises, because there is more what? Kinetic energy, it has more kinetic energy, it means it has more, cold air cannot, it actually the opposite. The warm air here is actually moving out and you fell a bit cold. Thats the science. Now let me go back to my, and let suppose this wall is warm, right, let's suppose this wall is warm and I'm feeling cold right, if i lean on this wall, what's going to happen in terms of energy or transfer of heat

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Mr K: [...] from me to the wall or from wall to e?

Learners: from the wall to you

Mr K: which is the same story that you were talking about right, so it's from the wall to me not from me to the wall, now it terms of temperature, we are talking about heat neh if i were to measure the temperature of the wall, let's suppose there was a way for us to put our thermometer on the wall and measure the temperature change, are we going to see a drop in temperature or an increase in temperature?

Learners: drop

Mr K: it's going to be a drop neh, because some heat energy has been transferred to me, okay and maybe on my part what's going to happen to the temperature,

Learners: increase

Mr K: it going to increase because I'm transferring what energy, now let's look at this reaction, if now i have my thermometer here and there is a reaction taking place in here right, let's suppose that the initial temperature is20 degrees Celsius and her you have a final temperature of let's say 30 degrees Celsius and then in another one again you have, you have that, you have your thermometer again, you have your initial temperature as 20 and then you have your final temperature as 15 degrees Celsius, right. Now we are talking about temperature, now then temperature here was 20 then it decreased to 15, was there energy released or energy absorbed?

Learners: [realised /absorbed]

Mr K: was there energy released or energy absorbed, lets here Learner M?

Learner M: energy released

Mr K: energy released, okay, any else with a different answer? Yes Learner T? Energy released or absorbed

Learner T: absorbed

Mr K: absorbed? Okay where is learner V?

Learners: [Absent]

Mr K: absent, ah Learner H?

Learner H: absorbed

Mr K: absorbed? How do you explain that, how do explain it, someone?

Learner H: [...]

Mr K: but you can see that energy is absorbed, do you agree?

Learner C: i disagree sir, i think energy is released

Mr K: you think energy is released? Okay, now we are talking about temperature, don't confuse temperature and heat, now i know as i said, if you were to calculate the temperature change neh, change in temperature you are going to say t final – t initial and your delta t is going to be, what is your final temperature?

Learners: 15

Mr K: 15 your initial temperature is going to give you what (20), o you are going to get how much

Learners: -5

Mr K: negative 5 degrees Celsius, so the change in temperature here is minus 5, now is this a degrees or increase in temperature?

Learners: decrease

Mr K: is an increase?

Learners: decrease

Mr K: decrease right, so in order for temperature to decrease, must it be released or absorbed, for you[..] does it mean that the system here, we are talking about reaction were the reaction is taking place is our system, in the system release energy or absorbed, took energy from the environment

Learners: [released-absorbed]

Mr K: okay now, take note the thermometer is actually measuring the temperature of the what, the environment, is measuring the temperature, look at my example here. Right when i said, uhm I'm here at the wall, this is warmer, I'm cold. The thermometer is there, is this wall going to loss heat to me okay, what going to happen to the temperature here?

Learners: decrease

Mr K: it's going to decrease, because it's what, its losing now there is a relationship between heat and temperature the two are [...] right, if there is more heat it means that the temperature is going to what, increase. If there is less heat it means the temperature is going to what? Drop. This (pointing to the wall) is going to experience a temperature drop why because of transfer from the wall to me, we expect a temperature drop here, this is what we are seeing here this one is starting from 2o degrees and dropping to 15, so was energy released or absorbed here

Learners: [released, absorbed, released]...

Mr K: its quiet interesting neh

Learners: yes

Mr K: there actually energy absorbed here

Learners: [ahhh sir, yes, ahh sir]

Mr K: okay let me try and give you a different [...], okay lets go to this one, if you were to find the temperature change, this is going to be t final minus that neh, our final here is how much minus our initial is how much 20, this is going to give us a positive answer 10 degrees, plus 10 degrees right, now where is this, in this case was energy absorbed or energy released there/

Learners: [released, absorbed, released]

Mr K: released? So it's released and released again? so here it was released because the temperature was 20 now it has released to 30, so energy was released here, then the temperature was, yes?

Learner U: ah sir, *bo sheba, if ore energy ka da decreases, okay, what if relationship between energy and heat, they are directly proportional akere? Which means whenever heat i increaser, heat yetsang mener, ya increaser, akere mener, so hare a system yarona, which means heat yetsang mener ya decreaser, le temperature itloyetsng itlo decreaser (look if you say energy in there decreases, what is the relationship between energy and heat, they are directly proportional isn't it? Which mean that whenever heat increases, what does heat do it increases sir, it increases sir, isn't it sir? So in our system, this means heat decreases, temperature will also decrease)*

Mr K: where here?

Learner U: yes

Mr K: okay, so

Learner U: energy will be released

Mr K: energy will be released here?

Learner U: yes sir. And then ka yi itloba absorbed (then this side is going to be absorbed)

Mr K: itloba absorbed (its going to be absorbed)

Learner U: No, dili two intloba energy released (both of them its going to be energy released)

Learners: [laughing]

Mr K: it's very interesting neh, thats why i said you need to look very closely they can...there is an endothermic and exothermic reactions, it's easy when we are talking about heat but when it comes to temperature is not easy, yes learner B?

Learner B: i think sir in this first energy diagram energy will be absorbed, it will require energy sir for temperature to degrees and then in the second diagram energy will be released because it is forming sir, it forms, it forms an atom thats why the energy will increase, thats how i/..

Mr K: that how you understand it?

Learner B: yes

Mr K: okay good, let hear learner Z there

Learner Z: [....] exothermic [...] akere?

Mr K: Jah that’s interesting

Learner Z: that means kore (that’s means that) [.....]

Learners: [Yesss]

Mr K: interesting yeah, okay, yes

Learner R: energy and temperature sir, you said heat is a form of energy sir

Mr K: yes

Learner R: now in this subject you said like heat and energy are different and then in the exo and endothermic you are explaining it through heat and then here is temperature sir, now from the examples that you gave us yesterday sir, you said out of the environment into the system they will be the breaking of bonds, akere sir (isn’t it sir) that means kege (what is it) absorbed, energy is absorbed, when a bond breaks which means they is an absorption of energy

Mr K: of energy?

Learner R: yes sir

Mr K: okay, now it seems like now you have something to say? How do you understand this just to hear your view?

Learner D: I don’t know sir, i think its absorption

Mr K: you think here is absorption

Learner D: and that side is released

Mr K: released?

Learner D: yes sir

Mr K: how do you explain it?

Learner D: I said is absorption because here sir [....] like sir as as he already mentioned, there there, thats the point i just said, akere as you were demonstrating there, the wall is much warmer than you are, the wall, its temperature is increasing and your is decreasing, i think there is absorption sir, because as you said yesterday in the environment, i don’t know how to explain it sir,

Mr K: you know how to explain it

Learner A: sir, can i ask something sir, between thermometer and that ntwena that thing) kef eng (which) is the environment, thats way i think there is a confusion, okay like maybe, okay sir, as o buo more (as you said) kopa obotsa (can I ask) that thermometer ke wena (that thermometer it's you) and that ke (its) the wall?

Mr K: uhm, okay i will come back to you, leaner L you have something to say, i thought you wanted to say something? Alright in this case what I'm saying is that if the thermometer is here inside the wall, its measuring the change in the temperature within the what the wall, okay within the wall, if its within the wall and i came in contact with the wall, the wall is going to loss, you said its warmer than me, heat is going to be transferred from the wall to me, so its losing heat to me, are we together on that one, so its losing energy from the wall to me, what is going to happen to the temperature within the wall is it going to increase or decrease? To decrease right? That one is clear, it going to decrease because it's losing what energy, okay as i said there is a relationship between energy and heat, maybe if i had a thermometer, i would put it on my hand which they normally do, i have a thermometer and then i measure my new temperature, is it going to increase or decrease? Increase, because i have gained energy, now lest go back to here, this thermometer is in contact with the contents of the neh, with the contents of this, whatever reactants were there initially the initial temperature before the reaction was 20 that the initial temperature right, the reaction takes place we record a lower temperature, does it mean there is decrease in what, in temperature, so in terms of energy did the energy of the system increase or decrease, did the energy inside here increase or decrease

Learners: decreased

Mr K: it decreased right, if the temperature drops that means the energy also what decreases, so where is the energy gone? It's actually taken by the reactants inside here. Okay remember here we talked about bond breaking and bond formation, so the energy is actually within the bonds, it part of the reactants, it's something which is microscopic you cannot see it, the energy is gone within the bonds that part of the enthalpy of the new products. It actually means that the new products have more energy than the reactants. The products have more energy than the what, the reactants, which therefore means that this reaction is actually what endothermic reaction, this is an endothermic reaction, now look at this one now you start with 20 you end with 30, there is a rise in temperature, here there is a temperature drop and here there is a temperature rise. Now let's look at the temperature rise, the temperature has risen by 10 degrees, now in terms of heat what is happening, is this reaction, what can you say is it absorbing or releasing energy?

Learners: It's releasing

Mr K: it is releasing, because you can see that the temperature is what is increasing, is that so?

Learners: [yes]

Mr K: from 20 to 30, this temperature is recording a now what higher temperature, because there is heat here which is actually [...] which tells you that the reaction is actually what exothermic, now i know the confusing you don't have to link this with delta H, this is not delta H these are temperature changes. So a negative temperature change actually indicating an endothermic reaction, its telling you that this has been absorbed not released okay and here the plus 10 degrees has gone to the environment, okay so initially this was 20 and there is an addition of 10 degrees inside now, thats what the temperature has risen the thermometer is actually reading the temperature inside there is the temperature was 20 and then, it changed to what to 30, which means that they heat involved because temperature cannot increase when they is no heat released, temperature is a function of what of heat the two are related more heat. More heat more temperature> i see that concept is trick, you will understand that when you do the experiment, as i said that we will do experiments on this then, we are going to unfortunately the ones that we are going to do involve temperature changes and you are going to see dropping in temperature and rising in temperatures and its actually going to make sense, when you do the practical right, you are going to see how an endothermic reaction behaves and how an exothermic reaction actually behaves, in those experiment which will actually carry out, most of the endothermic reaction are actually phisi right, you actually see the [..] of the [..] produced and actually even the reaction vessel if it a beaker it feels warmer, if you hold it, it feels warmer, because energy is actually being released and therefore you are going to see a rise in temperature......so in the next lesson I'm going to bring work sheets to actually see

<u>Practical Transcription: Mr Kufa **(00000)**</u>

Mr K: ..Are there is still space there, let's not. So the other groups can move there, I will bring the chemicals that you guys are going to use. *So what you are going to do is, you are going to classify the types of reactions that we are going to do, I will provide the chemicals as I have said and* ***also*** *a thermometer, righ*t. So what it means is that the initially, at the beginning you need to measure the **initial temperatures**, right?

Learners: Yes

Mr K: of your reactants and you need to measure the **final temperature** when the two have reacted and then from that information, you are going to perhaps ah *classify the reactions as whether exothermic or exo-?*

Learners: *Thermic.*

Mr K: depending on the temperature changes that you are going to record and also I also require you to write balanced equations, right for those reactions for the chemicals that I'm going to give to you, okay?. And you must also do a write up; I'm not going to tell you how to do it, okay. In this lesson, everything is up to you but you must be very careful as to how to handle chemicals. One of the requirements as a science student, you need to know how to handle chemicals. So as I said I'm going to provide one person per group with this […] (01:47) right, so that person will be the one which is going to handle, you don't use naked hands neh, so I will need a write up for each group, you are going to decide how you are going to do the investigation, okay. Now, let me just give, let me have one person per group to just come and get the glass beaker, ah hello (handing out gloves to the students and also the glass beakers).

00002 (2)

Mr K: now, let's ah, I think with this one, you have recorded neh?

Learners: Yes

Mr K: the important thing for you here is to have the results, make sure that you have the results, draw a table of results, have your initial temperature and your final temperature and as I have said, although it's not it's not the purpose of the experiment to balance the chemical equations. You need to the skills, make sure that have your reactants and products and you must know how to balance them. But as I said the important thing is *to get the temperature changes*. Now I have given you the small test-tube, it's actually better because your thermometer is actually going to dip, okay. So the next one that you are going to do, you are going to have water reacting with sodium hydrogen carbonate ($NaHCO_3$). So the first thing is you are going to pour the water, where is the water, alright. So you have your water there, you mustn't have a lot. So in chemistry we don't need large quantities neh, you just need small quantities to make observation, it doesn't mean that for a reaction you must have a bucket full of chemicals right.

Learners: [Laughing]

Mr K: small amounts and make what? Observations. So just small amount there is fine, and then dip your, just make sure that you rinse thermometer. Just find a tissue and wipe and dip again and then are. Those with tests tubes, group leaders can you come and fetch the water and then you do the same thing; *clean your thermometer and then dip in water, get initial temperature,* I will bring the next chemical okay. (Pouring water into the beakers brought by learners). Okay guys, can you listen pay attention please, so the next thing is you are now going to dip your thermometer, after cleaning in dip in there are have your initial temperature, I will come when you have your initial temperature then I will put the next chemical. (03:23). Okay, make sure that you do not touch the hydrochloric acid and sodium hydroxide, they are highly concentrated right, and you know that they are corrosive Neh. Those are some of the things that you must know...

Mr K: (pours the […]) just stir and then you stir; you have recorded the initial temperature?

Learners: Yes

Mr K:

(Learners Observations)

Mr K: okay, thank you, seen anything happening there? Your temperature change neh, if you are observing something interesting, have your recorded your initial temperature?

Learners: Yes

Learner A: what’s the temperature?
Learner B: 15

Learner C: nkare le rate 15 (It’s like you like 15)

Learner A: akere ne ele 12 (it was 12)

Learner

Practical Transcription: Mr Kufa**(00000)**

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00002 (2)

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Mr K: (pours the […]) just stir and then you stir; you have recorded the initial temperature?

Learners: Yes

Mr K:

(Learners Observations)

Mr K: okay, thank you, seen anything happening there? Your temperature change neh, if you are observing something interesting, have your recorded your initial temperature?

Learners: Yes

Learner A: what’s the temperature?
Learner B: 15

Learner C: nkare le rate 15 (It’s like you like 15)

Learner A: akere ne ele 12 (it was 12)

Learner

00001 (3)

Mr K: Shh, can I have a group leader right; bring your one of your beakers, one of the containers.

[Mr K proceeds to pour chemicals (HCl) into the beakers that learners brought]

Mr K: Okay, what I have done here is. I'm trying to avoid you guys using big amounts neh, of this chemical. Now I'm going to provide you with thermometers that you are going to use. Can I again have the group leaders, just come and take one thermometer. Take this one, who is the other one?

[Mr K is handing out thermometers]

Mr K: I hope you now have thermometers, please make sure that you don't touch at the tip of the thermometer, because the thermometer will give you the wrong results because it's recording your own temperature. So do not touch near the tip, okay. So now can you just place the thermometer inside the contents, what you have put there is hydrochloric acid, so you must write down. So you have your acid, so make sure that you have your thermometer inside there and then, put it for a while. Is your thermometer inside your flask?

Learners: Yes

Mr K: okay, good. Now what I will do is, I will just come and pour the sodium hydroxide and you will have to take note of what going to happen, and if temperature changes, okay. So I'm just helping you.

[Pouring NaOH into the beaker with HCl, learners are observing]

Mr K: don't put your nose there, this one is sodium hydroxide

Learner A: ah iyatshisa, iyatshisa (Its hot, it's hot)

Mr K: please take note of the differences there.

*

Mr K: so did you record the initial temperature?

Learner R: No

Mr K: you must write the initial temperature, how are you going to see the increase, record.

Learner R: ke e, ke 10. (Here it is its 10).

Mr K: you just have to do it this way [stirring the thermometer inside the HCl solution], make sure that it's inside there, you can observe. Who can take note, the group leader? Don't be scared of these things, are you scared.

Learner T: Ke 50

Learner S: iyatsamaya (its moving)

Mr K: make sure that the tip of the thermometer is inside there

Learner R: Yes

Mr K: Okay, so you have recorded that, hold

Learner R: ke sodium hydroxide akere (its sodium hydroxide isn't it)

[Mr K pours NaOH into the solution of HCl]

Learners: Ehhh.

Learner V: keng ke 65? (What is it, is it 65?)

Learner R: 65

*

Learner D: re sharp ka nto enyane (We are fine with a small thing)

Mr K: its better this way, you record your initial temperature.

Learner C: ke bo kae (how much is it)

Learner B: in tse ele ko 20 (it was at 20)

Learner E: a e change (it does not change)

Learner D: initial gwala initial (initial write initial)

Mr K: have you recorded

Learners: yes

Mr K: there we go, let's have uhm [pouring NaOH into HCl]

Learner B: ya yatshisa sulphuric e (Yuh it's hot this sulphuric)

Learner E: ke 4o vele? (Is it 40?)

Learner F: a e 40 (no it's not 40)

Learner E: e fetele? (Did it pass?)

Learner B: arere 50 (let's say, 50).

Learner C: make it 60 something

Learner D: yetsa 60 something (make it 60 something)

Learner C: ware beaker ya tshesa? (Are you saying the beaker is hot?)

Learner B: e ya (Yes)

Learner E: Yatshesa nto o? (Is that thing hot?), o gwale everything ere e observang (write everything we observe)

Learner G: a se beaker mare nto e (it's ot a beaker this thing)

Learner E: wo, ema nyana (Oh wait a minute)

Learner G: mara a se beaker (but it's not a beaker)

Learner E: okay ke test tube ge (okay it's a test tube), gwala gore test tube ya tshesa (write that the test tube is hot) and then le colour change (and the colour change)

Learner G: yellow

Learner E: I white byanong (its white now)

Learner F: I gold, it's something like baig, like the light version of baig

Learner D: I violet

Learner F: colour change, ne ele goldish, ne ele yellow. It's the lighter version of baig, you can go to the internet, they will tell you gore (that) its baig

*

Learner A: ya increaser? E temperature ya increaser (Is it increasing, the temperature is increasing) gwala (write) initial temperature and final temperature.

Learner H: now, ke bo kae now? (how much is it now?)

Learner A: 10.4 and ya increaser (10, 4 and its increasing), wo a e relaxy ntwena (it's not relaxing). Ya increaser fela (its increasing only). Ya increaser akere pele e ne ele 10, 1 now e se ele 10, 5 (its increasing at first it was 10, 1 now its 10, 5.

Learner G: colour change

Learner A: ke e colour change wabo (here is the colour change you see)

Learner J: a o gwale, colour change (write colour change)

00003 (2)

Mr K: Now bring another one, okay imp going to bring one more.

*

Mr K: you guys you say thermometer is having a problem?

Learners: Yes

Mr K: okay, try this one. Jah try that one. Is there someone who is mixing the other things there, I can smell. Okay, you guys you must also come and get a beaker

*

Mr K: okay, where is your test tube. Can you put that in here, let’s have water first. Pour water there

Learner M: [pouring water into a small test tube]

Mr K and measure the initial temperature

Learner N: Sir what’s that?

Mr K: [giving Learner N a container to read]

Learner N: (reading) ‘vitamin C’, haaa.

Mr K: measure the initial temperature, then

[Mr K breaks the vitamin C into the test tube with water]

Mr K: okay, you stir it neh.

Learner M: [stirs]

Learner O: okay, ena le smell (okay, it has a smell)

Learner P: e sale emo 15? (Is it still on 15?)

Learner M: e te ohile (it has increased)

Learner N: ke bo kae? (How much is it?)

Learner R: e eme ko 20 (it has stopped at 20)

*

Learner F: […] Eno neh, eno ba etsesti ka pela (Eno, neh but this one they pour fast) [referring to the vitamin C]

Learner G: why nkare I very reactive in water? (Why is it reactive in water?)

Learner H: temperature ya increaser

Learner F: ya decreaser, ha nyane (Ja its decreasing, slowly)

Learner H: Jah ha nyane (Ja slowly)

Learner F: le colour iba dark (and the colour is becoming dark)

Learner G: I constant

Learner H: Ya mara ha nyane ha nyane (Ja but slowly but surely)

*

Mr K: okay, so you need to record again your initial temperature, right?

Learner A: of the water

Learner B: a e movi (Its not moving)

Mr K: then ah, you have to record it neh, so its water and vitamin C. you will have to come up with the formula there, alright let's see...

Learner C: wo, temperature mener (wait the temperature sir)

Learner D: its 15

Learner B: 15

Mr K: okay, let's go, can you just move the thermometer there, so that I put this for you. Then you stir, observe

Learner C: eh, eh, eh, sir why e, why e increaser ntwena? (Why is it increasing this thing?)

Mr K: […]

Learner B: ke bo kae? (How much is it?)

Learner D: 13

Learner C: yoh, ya decreaser, why? (It's decreasing why?)

Learner D: ya evaporater (its evaporating)

Learner C: ke vitamin C, obvious.

Learner B: ho tsho e wela under eng? (That means it falls under?)

Learner C: endothermic.

00004 (2)

Mr K: okay, let's do this one, as our last one. Where are the leaders, I will give the new test tube. In there imp going to pour sulphuric acid. So we have our sulphuric acid, we put little amounts, we don't do bucket chemistry. Okay guys, I think you know now what to do; you must have your initial temperature first. Do you have your initial temperature?

Learner T: what is that sir?

Mr K: this one is zinc, and your thermometer must be far. Hold and stir, you can even feel, feel what's happening there.

Learner U: gwala change of colour (Write change of colour)

Learner W: a e tshise? (Isn’t it hot?)

Learner V: [nodding NO]

Mr K: what did you see?

Learner T: there is only colour change

Mr K: there is not temperature change?

Learner V: Sir, the temperature it seems like its decreasing

Learner W: initial ne ele bokae? (Ow much was initial?)

Learners: 17

Mr K: what happened to the temperature?

Learners: It decreased

Mr KJ: it’s decreased?

Learners: Yes

Mr K: there is something you didn’t well

Learners: [laughing]

Learner V: which means de wrong delo tse re de gwetsi (that means what we wrote was wrong)

00005 (2)

Mr K: okay, alright guys. Now guys, now you have the results right, what I want you to do is, I hope you guys are also done. You just finishing up

Learners: yes

Mr K: you record your temperature immediately when there is a change, you don’t wait for long, for you to, that’s why some of you are recording different temperatures, I have noticed. The moment you mix them, that when you must record the temperature change. We don’t wait, maybe stir and stir and maybe after 20 minutes, because then they will be a lot of things that […], so the temperature is supposed to be read the moment you mix with the other reactant, that where you must record that temperature. And also there other thing is that your thermometer, when you look at your thermometers, some of you we saying some of them are not working, yes there are some which are not working. But I also realised that, you see this part, this bulb is the one which is sensitive, right. So it must be in contact with what you are measuring, if it’s up there it’s not measuring the temperature of what is supposed to record.

Like if it's hanging in the air like that, you put it there, you will be measuring the temperature of the atmosphere not of the substance. So always the thermometer must be in contact with the reactants for you to record the temperature inside there. So its also very important, so now you have your results, I want you as I said to do the right up and come up with a hypothesis, your aim, you know how to do a write up neh. All those things and also for each experiment, you must have a balanced equation, what was happening, reactants to give you products, those products must have names, you must balance the equation, tell us about the delta H of that reaction neh. Of course here we were not measuring delta H, we were not measuring heat we were measuring what?

Learners: Temperature

Mr K: temperature, so you have to be very careful with measuring temperature and how temperature is related to what, heat, very important. So conclusively, we can say for now we are done but just go do the write up and from there we will see were some of you had, especially the relationship between heat and temperature, where did you have misconceptions, where is it that you had what, problems. And then in the next lesson, we are going to discuss the experiment and perhaps I will do a demonstration of all the experiments and record again the new results that we are going to get as a class. Discuss them, and I also have worksheets that you are going to have for the next lesson, for you to try get answers, to see if you guys understood this whole concept.

Peer Engagement Session transcription

This transcription is from my peer engagement session, where I had to meet up with my collaborative team and present my pre-CoRe for validation and critique. What they did was give me feedback on my pre-CoRe.

[…………] Audio unclear.

SP: *So, if we look, I mean within literature what big idea.*

C1: *Big idea is?*

SP: *Iya, what big ideas are, I mean one thing for sure its saying it's not your subatomic.*

C1: *Topics?*

SP: *Sub-topics, (laughs) it's not subtopics, it would be those ideas which basically are holding the topic together.*

C1: *Jah.*

SP: *Okay and basically collectively all the big ideas which you going to, if you put them together, they should be addressing all the concepts, maybe at that level, at that particular level and maybe we could say these do okay? But Im asking myself are these big ideas or they are subtopics? You know?*

C1: *When I looked at them I thought they were topics.*

SP: *Okay, subtopics.*

C1: *Iya, I thought they were subtopics, but there is a bigger idea, there is a big idea that would embarrass all of them, if you understand, for an example one of the things, coz I'm teaching energy as well if we say energy is a big idea, you understand that if they don't understand what energy is, they will not understand what happening here (pointing on the hand-out) when you talk about an open and a closed system, if they don't understand energy they won't understand exothermic and endothermic, if they don't understand energy; work force and energy, ah I think research also shows us that these are always mixed up. You know what I mean?*

SP: *Okay, okay, before you go on Xolani, we are using the CoRe.*

C1: *Yes.*

SP: *..And the Core is offered by Loughran and these are, maybe literature, are related to this isn't it?*

C1: *Yes.*

SP: *I mean in their work.*

C1: *Yes.*

SP: *..And we need to, if you are using a tool which they have developed, we need to be looking at what do they consider as big ideas; and part of it, it's not going to be one word, it's going to be a statement.*

C1: *Iya*.

SP: *Okay, It would be, I mean the idea it should sort of take care of, what do you call it? Show interrelationships between several concepts, around a big ideas should cluster several related concepts, neh? So a big idea maybe should be expressed as according to them as a* *statement, you know. Like I was saying collectively it should be ideas that are holding the topic together into a comprehensible whole, like I was saying within each big idea, one big idea would pull together a cluster of related concepts neh, and then another thing about the big idea; according to them. Okay that big ideas would deal with relationships between what is observable about the phenomena and the scientific explanatory model, so it will deal with, I mean we have the macroscopic, microscopic, symbolic, neh. So what we are saying big idea it's an idea which basically will sort of express the relationship between, a class of phenomena okay and how scientists explain that phenomena okay, in a way that is helping us to understand how that phenomena maybe unfound or behave in nature, maybe ideas which are dealing with relationship between these two, what you are observing at microscopic level and how scientists explain that at macroscopic level, explanatory.*

C1: *Is it micro or macro?*

SP: *Macro, I mean micro, macro, micro,*

C1: *Okay.*

SP: *Yes, so there are big ideas dealing with what is observable about the phenomena and the scientific explanatory model used maybe to explain that phenomena, I will have […………], sorry I have this here….. And then we interrogate the big ideas maybe in that sense according to Longran and colleagues…. [……..]*

SP: *..And there if you look at it, it would be those ideas that hold a topic together, and have a profound impact on how scientists view's and conceptualise the world, okay. So from that statement you can see that its, okay, we are observing a phenomena microscopically and scientist have a way of explaining that neh? For instance using your what do you call it models, okay particulate models of matter and all that?*

C1: *So Uhm in in, in when his doing like collecting data, is there any specific topic that you gonna be looking at?*

SP: *His using this one, enthalpy.*

R: *Enthalpy.*

C1: *Uhm, I'm not sure if the conservation of energy as an idea could be ah, a big idea, you know what I mean? When energy is conserved and then, then what does that mean to say that, conservation, then we can take it from there, you know what I mean, to talk about all these things uhm.*

R: *Even this (pointing at a worksheet)*

SP: *That your first, is it first law?*

C1: *Yes*

R: *Jah, even Hess law has conservation of energy*.

SP: *Yes, but now with the practical you are going to be focusing on this and indeed I mean with enthalpy, I mean what is our understanding of enthalpy? Or what are ideas related to enthalpy, you know I thought about this one idea related to that would be basically both your chemical processes and physical processes are driven by decrease in enthalpy, either decrease in enthalpy or increase in entropy or both. Basically that would be a big idea, you know, that all the physical process, physical and chemical processes are driven by a decrease in enthalpy, and increase in entropy or the combination of both, you know and then maybe another thing you talked about conversation of energy, so that would lead us to maybe internal energy of a system. Isn't it internal energy of the system would be he sum of your kinetic.*

C1: *Jah.*

SP: *And your potential.*

C1: *Jah.*

SP: *Isn't it?*

SP: *Iya, but then that's exactly the interest ya Kabelo, in the sense that, aint you moving in with a strategy of trying to help them. Basically he is trying to, they are going to be observing maybe phenomena, basically in the lab its microscopically isn't it, like mixing and all that, handling em the what do you call it?*

C1: *Chemical.*

SP: *Chemicals, at bulk level, but he is trying to intervene, to help them, as they are observing to try to reason, at macro, microscopic level to ask themselves what is actually happening to the system, you know. And indeed maybe even shifts here symbolically, the practical work if you look at that, we need to be looking at that practical itself and see where the relationship between the macro, the micro and the symbolic actually and then try to help Kabelo to say what types of probes you can have to try, so that they don't just observe at that level, macroscopically. But he is probing all the time see, but what is really happening to the system.*

C1: *So for now*.

SP: *Em would be misconception, common misconception which learners would have about energy role in bond formation.*

C1: *Yes.*

SP: *..And bond breaking and that would come out as a big idea also, you know with the energy is required for bond breaking and energy is released during bond making. It could be a big idea, which sort of talks to this, the endothermic and exothermic, you know?*

C1: *Uhm, so, please say that again?*

SP: *Em, energy maybe you would say energy is required to break the bonds*.

C1: *Okay*.

SP: *And energy is released during bond formation.*

SP: *Oh yes, that what to address actually, that's what the common misconception here, because with these graphs. Okay normally, you are going to talk about energy neh? When we talk about the energy of breaking bonds and all that you are about potential energy isn't it?*

C1: *Yes.*

SP: *Okay, we are talking about potential energy but what you going to be doing is measuring using a thermometer okay, so when the energy of the system is changing what do you call it?*

C1: *Kinetic?*

SP: *That's okay either is it kinetic, potential, but the graph would be different if it Ek isn't it and if its Ep.*

C1: *So I'm not sure if it correct for me to say, if we using a cox these graphs Ep isn't it?*

SP: *But you can express them, normally they are expressed as Ek isn't okay, but the thing is that's another thing I think at the core of your strategy or what will be types of misconceptions, they are going to be measuring using a thermometer, so their measuring temperature change and normally they would confuse Ek with Ep, they for instance exothermic reactions energy your what do you call it? You're your products are at.*

C1: *Lower temperature than.*

SP: *lower energy*.

C1: *Energy*.

SP: *Your products are at lower energy*.

C1: *This is what I want.*
