CHAPTER 1

INTRODUCTION AND BACKGROUND TO THE STUDY

1.1 Introduction and Rationale

The under-performance of learners in South Africa (TIMMS, 1999) in Mathematics and Science has become a general concern. According to the TIMMS report as given by Howie (2001) of the Human Sciences Research Council, the shock of South African pupils' low performance in Mathematics and Science actually "reverberated around the country for quite some time" (p. 3). The TIMMS report offered a number of reasons as to why the performance of South African pupils is poor in Mathematics and Science compared to other countries of the world. The reasons encompass a range of areas such as learner home backgrounds, poor self-concept of learners in Mathematics and Science, poor preparation by educators (in most cases inexperienced and unqualified teachers are teaching these subjects in most South African schools), and under-resourced schools.

The discovery by the TIMMS study that "South African learners have a very poor self-concept in Mathematics and Science compared to pupils internationally" (Howie, 2001, p. 37) is worth considering. This implies that South African learners perceive themselves as not talented enough to do well in either of the subjects, that the two subjects are difficult and that they cannot find any joy in learning the two subjects. Research has shown that the notion of self-concept has an influence on attitude towards learning (Young, 1998).

The style of teaching and learning in class can be used to assist learners to develop the much needed self-concept within the Mathematics and Sciences learning areas. However, to achieve this, the mode of teaching in the classroom has to be strategic and have a clear purpose in mind. For a lesson to be strategic and purposeful, a high level of teacher preparedness is required.

This study investigates the effects of context–based instructional methodology on learners' interest and performance in Science. The context–based teaching approach, which is rooted within the Science-Technology-Society (STS) ideas on the teaching and learning of Science, challenges "the traditional views of teaching Science held by many teachers that teaching Science is simply a process of transmitting long lists of concepts and students are merely the recipients of knowledge" (Tsai, 2001, p. 37). The National Science Teachers Association in the United States of America (USA) has defined the STS approach as the teaching and learning of Science within the human experience (Yager, 1992). The context-based STS teaching approach emphasizes the use of societal issues as starting points for Science learning rather than scientific concepts (Holbrook, 1992; Yager, Tamir and Huang, 1992; Ramsden, 1994). It aligns itself with the notions of the modern ideology of constructivism in learning in which the learning process is viewed as being constructive rather than rote in nature (Glynn, 1995). Glynn (1995) claims that constructive learning of Science is seen to be a dynamic process in which knowledge about the natural world is built, organized and elaborated; this results in the formation of conceptual models in the minds of those involved in the learning. The use of a cognitively effective teaching approach is vital to make learning meaningful. For that reason in the past two decades,

> "… there was much concern about the failure of typical science teaching (traditional teaching methodology) that seemed to focus on transferring information from instructor to students. It was assumed that nearly all students could learn what curriculum guides, textbooks, and teachers defined as important science concepts" (Yager, 1995, p. 36).

This is what I refer to as the traditional mode of teaching. Research has shown that there is very little evidence that meaningful learning can occur by the simple transference of knowledge directly to learners, which characterizes the traditional mode of teaching, unless learners themselves engage in a thought process which is often initiated by a problem or discrepant event (Yager, 1995). This problem or event is scientific in nature and can serve as a basis for a lesson (even for a series of lessons) in a classroom.

Kasanda, Lubben, Gaoseb, Kandjeo-Marenga, Kapenda and Campbell (2005) add that, apart from using these scientific events or problems as starting points for lessons in the classroom, context-based learning methodology takes into cognizance learners' everyday experiences and uses contexts to allow maximum learner participation in class. The discussion on the contrasts between the traditional and context-based teaching approach is continued in Chapter 2 of this study.

The newly-introduced curriculum in South Africa, the National Curriculum Statement (NCS), in the Further Education and Training (FET) band for Physical Sciences, encourages educators both to contextualize their lessons as a way of bringing about curriculum relevance and also to ensure the attainment of scientific literacy by the general public (Department of Education, 2003). Context-based teaching is claimed to be one of the approaches that could assist in improving scientific literacy levels amongst students.

1.2 Purpose and Objectives of the Study

1.2.1 *Purpose of the Study*

The overall purpose of this study was to investigate the effects of a context–based approach to the teaching of Science. The study investigated whether the context–based teaching approach is capable of generating interest amongst learners towards the learning of Science. Learning is a cognitive process and research has shown that "interest has a powerful facilitative effect on cognitive functioning" (Hidi and Harackiewicz, 2000). The study further looked at whether the generated interest, if any, amongst learners led to any improvement in learner performance. Hidi and Harackiewicz (2000) identified interests and goals as the two most important motivational variables with a direct impact on the academic performance of individuals. The goals of learners in the ***Science Benefit Group***, discussed in Chapter 4 of this study, serves as the motivation for them to do Science at school. For this reason, Anderson and Simpson (1981), state:

> "An important goal of science is (and must be) to develop in students positive attitudes toward science. Not only do students with positive feelings towards science achieve more, but they are also more likely to incorporate science into their daily lives when they appreciate its importance. For this reason science teachers should strive to make their subject interesting and their classrooms an environment where positive feelings and values are fostered" (p. 278).

The ***Social Oriented Group*** in this study indicates the importance of making classrooms interesting and fun places for learners.

Although research on the relationship between attitude and achievement provides mixed findings (Koballa, 1995), Johnson (1981, p. 39) argue that "attitudes help shape achievement, determine whether students will want to take unrequired Science courses, and encourage or discourage students to pursue Science-related careers".

Anderson and Simpson (1981) simply define interest as the willingness to respond to something and an attitude as the disposition to respond either negatively or positively towards phenomena. On attitude toward Science, Koballa (1995) and Koballa and Crawley (1985) define the term as referring to that general and enduring feeling about Science which is either positive or negative. Hidi and Harackiewicz (2000) define interest as:

> " … an interactive relation between an individual and certain aspects of the environment such as objects, events, ideas, and is therefore content specific. … a state and … a disposition of a person, and it has a cognitive, as well as an affective, component" (p. 152).

Hidi and Harackiewicz (2000) continue to distinguish between individual interest and situational interest across individuals. Whilst individual interest is seen to be a personal disposition that develops over time around a particular topic or domain and that leads to increased knowledge, value and positive feelings, situational interest is seen to be "generated by certain conditions and/or stimuli in the environment that focus attention, and it represents a more immediate affective reaction that may or may not last” (Hidi and Harackiewicz, 2000, p. 152).

Both the given definitions on interest indicate that interest is something that can be generated and developed. For Anderson and Simpson (1981), the generation of interest amongst learners towards Science should be part of the goals of Science teaching. This type of interest will be situational in nature, according to Hidi and Harackiewicz (2000), as it is focused on a group of pupils in a classroom. As said in the definition, this type of interest may or may not last. One of the duties of a Science educator should therefore be to sustain generated situational interest with the hope that it may change into a personal one which is more sustainable. The two definitions of interest also indicate that when an interest towards a particular object, phenomenon and/or idea is generated, it leads to a positive feeling by individuals towards such ideas. This ‘feeling’ can be called an attitude. Fishbein and Ajzen (1975) define an attitude as a learned disposition which allows an individual to display either a favourable or unfavourable response in a consistent manner with respect to a given object. Young (1998) agrees that attitudes are learned and that teaching can be geared towards the attainment of specific attitudes. According to Young (1998), there are many influences on attitudes. These influences include amongst others: gender, teaching strategy, teacher attitude, learning environment and pace of learning. Both teacher attitudes and strategies have been revealed in this study as some of the influences that led to the development of negative attitudes towards Science at the school in question.

The context-based approach to the teaching of Science has been used as a purposeful and strategic way in this study to investigate whether this type of approach to teaching does generate interest amongst learners towards the learning of Science. The underlying assumption is that the generated interest and the attitudes thereof will affect behaviour and lead to the development of positive attitudes towards Science amongst students and will then lead to meaningful learning (Young, 1998). It was also hoped that the use of a context-based teaching approach would serve as a vehicle for the creation of a conducive classroom environment that will enable effective teaching and learning to occur.

1.2.2 *Objectives of the Study*

On the issue of stimulating learner interest in doing Science, Anderson and Simpson (1981) suggest that "extra planning and the use of teaching strategies to develop interest among students can be an excellent investment of the teacher's time" (p. 279). This study was based on two main objectives:

- investigating whether the use of a context-based teaching approach leads to the generation of interest and positive attitudes towards Science and hence
- examining whether the use of a context-based instructional approach can improve learner performance.

1.3 Statement of the Research Problem

The basic question this study seeks to investigate is: ***what are the effects of a context-based teaching approach to the learning and performance in Science***. In attempting to provide an answer to this question, the study focused on the three research questions listed below:

1. does context-based teaching approach stimulate learner interest in doing Science and foster the development of positive attitudes towards the learning of Science?
2. to what extent does context-based teaching affect learner performance?
3. what challenges face educators who attempt to use a context-based teaching approach to the teaching of Science?

Teaching and learning in Science have been under an investigative spotlight for decades. For the past two decades, the emphasis of research in Science education has been mainly around 'cognitive Science' (Yager, 1995). Amongst others, interest in this area has been stimulated by the seemingly general under-performance in the subject and the low levels of scientific literacy worldwide. In the United States of America (USA), for example, the TIMMS study has revealed a similar case to that of South Africa (Blasie, Milne, Dai, 2001). Blasie, Milne and Dai (2001) of the Chemistry Education Department at the

University of Penn indicate the alarming discovery by the TIMMS study of poor learner performance in Science and how the number of learners pursuing Science-related careers at tertiary level have declined over a period of time in that country. Thus, although a significant number of learners in certain countries, especially first world countries such as England and America, seem to do better in Science compared to others, the general trend is that there is a global under-performance in Science and this is a cause for concern.

Reasons for under-performance in Science range from unmotivated students to poor instructional methodologies employed by educators as well as teacher attitude (Anderson and Simpson, 1981; Yager, 1995, Young, 1998; Hidi and Harackiewicz, 2000). This study aligns itself to the latter where it puts to the test a teaching methodology which has gained support within Science education circles as one of the effective instructional approaches that could bring about improvement in the teaching and learning of Science (Holbrook, 1992; Bennett et. al, 2005; Ramsden, 1994).

1.4 Significance of the Study

The National Curriculum Statement (NCS) in South Africa calls for, amongst other notions, a paradigm shift in instructional practices and the need to make teaching relevant in order to ensure that learning becomes more meaningful. Maximum learner participation in the classroom is encouraged. For this to be realized, a learner-centred approach to teaching is emphasized (Department of Education, 2003). This curriculum therefore places educators in a transformational process in which they are expected to overhaul their instructional practices from that of knowledge transmitters to one where they become facilitators of learning. For the Physical Sciences, in particular, educators are required to assist learners in developing skills in performing practical investigations. These practical investigations include both the traditional prescriptive laboratory work and those that learners will be expected to conduct outside the laboratory in the form of research. The curriculum also encourages educators to engage learners in laboratory work based on problematised situations/questions instead of the ‘recipe-like’ experiments where the results are known long before the practicals are conducted. An educator who attempts to use a teacher-centred approach in instilling these types of skills in learners has a very low chance of achieving his/her aims.

Although investigations into the effect of context-based Science teaching on learners have been conducted in other countries such as Australia (Bennet et al., 2005), very few have been done within the South African context (Doidge, Hlatshwayo, Molepo, Ngwenya and Shongwe, 2003 ICASE). This type of study becomes even more significant in the wake of the new curriculum which encourages the relevance of what is taught and the meaningfulness of what is learnt. The study is likely to assist in providing some solutions to the kind of challenges that face educators who attempt to use a constructive approach to teaching (context-based approach in this case) as envisaged by the third research question in this study. Although this research question does not have direct bearing on the purpose of the study, the importance of finding an answer to it in this study cannot be underplayed as the researcher's view is that learning is not separated from teaching.

1.5 Context of the Study

The study was conducted at a secondary school in Soweto, in one of the 15 Education Districts in the Gauteng Department of Education. It targeted 50 Grade 11 learners in a Physical Science class. The researcher and the regular Science teacher at the school co-taught the lessons during the intervention. A context-based module based on the topic of sulphur and sulphur compounds was designed by the researcher. The problems associated with the burning of coal as a source of energy were used as a starting point for the lesson. This is crucially important since context-based teaching, within the ideas of STS, emphasizes the use of a problem situation as a starting point for a lesson. The topic was chosen for its relevance and richness in terms of existing learner ideas and also because it relates to the composition of coal and the type of products formed during its combustion. The module was planned to run for two weeks during the winter season in 2006. The choice of this period was also deliberate as it coincides with the winter season in South Africa where coal is widely used as a major source of energy for both cooking and warming of both the surrounding houses and the shacks in an informal settlement less than 5 kilometres away from the school.

1.6 Participants in the study

1.6.1 The researcher

I am a qualified Physical Science educator with a four-year higher diploma in education (HDE) which I obtained in 1995. Teaching Science has always been my passion. In 2004 I completed my BSc Honours degree at the University of the Witwatersrand. I taught Science in the FET phase for six years. I have been relatively successful in teaching the subject as seen through the results I produced over these years. I served as a cluster leader for the subject in our area for most of the six years I spent as a senior Physical Science educator at my former school. The cluster forums provided the platform for us as Science educators to discuss ways in which the teaching and learning of Science in our cluster could be improved. Issues around teaching methodologies and levels of learner engagement would usually dominate our discussions. In these discussions, learners were normally labeled as being lazy and not showing interest. This is one of the reasons why I felt it would be necessary to probe why learners are losing interest in learning Science and what it is that needs to be done to stimulate them into wanting to take Science as a subject.

My current position as a Physical Science facilitator in one of the Districts in the Gauteng Department of Education (GDE) has given me an opportunity to engage Science educators on pedagogical issues on an even wider forum than the cluster level. These information sharing forums offer a rich base of ideas as far as Science teaching is concerned. For this research project, I have only researched the effects of one aspect of a topic frequently discussed: the effects of a particular teaching methodology on learner interest and performance in Science.

1.6.2 The Teacher

Mr Mawawa (not his real name) holds a three-year teacher's diploma in Physical Science. He is the Grade 11 Science teacher at the school where this study was conducted. He has been teaching Science at FET level (Grades 10 and 11) since joining the school. Although he has been at the school for more than three years at the time of the study, he has not been given an opportunity to teach Grade 12. At times during the study, Mr Mawawa would absent himself from school without reason. Learners would complain about this situation as they realized that they were missing much work. I believe this might have been the reason why he was not given the opportunity to teach Grade 12.

However, I believe that Mr Mawawa had reasons for absenting himself from school but perhaps needed somebody who would show interest in discussing this situation. As we co-taught the subject during the study at his school, Mr Mawawa showed a high level of commitment and was supportive as we planned for the two weeks' lessons. However, he would at times absent himself from school without even letting me know. When he came back I would talk to him about this issue. I would always try to wear my 'teacher's hat' and not my 'District Official's hat' whilst with him and this made him feel sufficiently at ease to speak to me in confidence. We ended up having a very free and open relationship. He even pointed out the weak points in his teaching without any fear of prejudice. He even indicated that there were subject areas in Science in which he does not have confidence and that he would like me to co-teach the areas with him as he would like to learn from me. This dilemma is discussed further in Chapter 5 under ethics.

Mr Mawawa's teaching methodology is that of a traditionalist (as discussed in Chapters 1 and 2 of this study). He believes in the 'chalk and talk' way of teaching. He prefers a class where learners listen attentively and quietly whilst he does the talking. This seems to be the mode of operation for most, if not all, teachers at the school. Learners are only engaged when he gives them exercises based on his teaching. Learners mostly engage in these exercises quietly as individuals but could ask the teacher for assistance. The teaching is test and exam based/orientated. Learners have to master those aspects of the topics as outlined in the syllabus to be able to pass the tests and exams, and eventually get promoted to the next grade. I believe that any conceptual understanding achieved by any learner in such a classroom happens by luck and not because of the efforts of the teacher in soliciting it.

1.6.3 The School

The school is well built with two-storey buildings. It is a kilometre or so away from the informal settlement. This is the main reason for choosing the school as a site for this research. Its proximity to the informal settlement made the use of coal as a starting point for the lesson on sulphur and sulphur compounds relevant to the learners. The learner community at the school comprises learners from both the township and the nearby informal settlement. The school does have running water and electricity. There is an administration building built separately from the classrooms. There is a functional telephone line and fax. Administration is done through the use of computers. Printers and photocopier machines are available.

However, the challenge in terms of resource seems to be in the classrooms. The school lacks furniture. There are insufficient desks or chairs in the classrooms. The available chairs and desks look old and most are broken. Most of the classrooms have a window or two broken or not closing properly. Most of the doors are broken. Many of those still standing cannot close properly. Because of the wind and the cold, it is, therefore, a challenge especially in winter for learners to be in these classrooms.

The school does have a Science laboratory. Judging by the available glassware and the few chemicals found on the shelves, the school once had a resourced Science laboratory. However, replacement of broken equipment or ordering of new chemicals to replace the finished ones has not occurred. The dust on the laboratory glassware and chemical containers also suggests that there little use is made of these resources. The learners' poor technical skills in the use of the apparatus used during the study showed that their exposure to laboratory work was minimal or non-existent.

1.6.4 The Learners

The average age of the learners of 11-D was 16. They were co-operative learners who would assist with everything you needed them to do. However, there was an element of non-commitment and 'non-seriousness' at first when we started. Learners would come to class late and drag their feet as they moved towards the classroom, even though the bell had rung a couple of minutes earlier. This seemed to be the norm for all the learners at the school. Learners showed no respect for time. It would normally take more than 10 minutes for learners to arrive and settle in the classrooms after a break or change of period. At the same time teachers looked relaxed and not troubled by the situation. During my stay at the school, very little was done by the teachers or school management to deal with the situation.

This situation was unbearable. I discussed it with my co-teacher, Mr Mawawa, and we took a decision to speak to the learners about it. We employed a period to talk about the importance of being on time for class and our problem was solved. Grade 11-D learners would rush for class every time they had to attend Science. This showed that the question of discipline should be a collective effort by teachers. We definitely wanted all learners to be on time for all classes and not for Science only. I discussed this problem with the School Management Team at some stage. Then the issue received the attention it deserved from both the teachers and the SMT (School Management Team) which resulted in an effort made to get learners into classrooms on time after breaks and change of periods.

1.7 Organization of the Study

This study is divided into five chapters.

***Chapter 1*: INTRODUCTION AND BACKGROUND TO THE STUDY**

This chapter provides an overview of the research problem, its rationale and the significance of the study. It also introduces the three research questions, the purpose and objectives of the study. Attempts are also made to give an overview of the type of methodology followed in the study with regard to research, data collection and data analysis. The chapter closes by addressing the issue of ethics.

***Chapter 2*: REVIEW OF RELEVANT LITERATURE AND THEORETICAL FRAMEWORK**

This chapter gives a review of literature relevant to the study. The STS notions on a context-based teaching approach to the teaching and learning of Science are outlined and discussed. The chapter further provides detailed discussions of three major learning theories within the notion of constructivism in learning, namely: cognitive, socio-cultural and the situated learning perspective. Apart from giving a general discussion on these theories, the chapter also looks at the implications of each of the theories for Science teaching and learning in the classroom. The lessons comprise the theoretical framework of this study as well as the insights on learning that the researcher gained. The learning was, of course, influenced by the researcher's strong belief in constructivism.

***Chapter 3*: RESEARCH METHODOLOGY**

In this chapter, details on how the research was conducted are given. The instruments used for data gathering purposes are introduced and explained. These instruments include questionnaires, interview schedules, a journal kept by the researcher, and the assessment tool (the test given at the end of the intervention).

***Chapter 4*: DATA ANALYSIS**

This chapter outlines the categories or themes in which data is analyzed. Interpretation of data is also given, based on summaries done, using tables and graphs. An attempt is also made in this chapter to link the emerging themes with the existing literature given in Chapter 2. For instance, the behaviour of learners during group work is viewed against Brodie's (2005) theory of the use of group work in class, whilst teacher moves are viewed against Bernstein's suggestions on classroom teacher practices that maximize learner-teacher interaction.

Chapter 5**: DISCUSSION, RECOMMENDATION AND CONLUSION**

This chapter provides a summary and the discussion of the results and their implications for the teaching and learning of Science. The chapter ends by offering recommendations and possible questions for future research.

1.8 Chapter Summary

This chapter introduces the study and lays down its rationale, purpose and objectives. It also provides the statement of the research problem together with the three research questions. The scope of the study is also given. The chapter also outlines the research methodology and ethical issues related to the study.

CHAPTER 2

REVIEW OF RELEVANT LITERATURE AND THEORETICAL FRAMEWORK

2.1 Review of Relevant Literature

2.1.1 Why the need for an STS approach to the teaching of Science?

Context–based teaching is rooted within the concept of Science-technology-society (STS). The STS notion mainly came into existence during the eighties. It was aimed at improving the Science curriculum and its method of teaching which were at the time seen to be irrelevant as they failed to provide answers to the new challenges facing global societies due to rapid advancements in technology (Trowbridge, 1990). Aikenhead (1994, p. 9), in support of the argument that the present Science curriculum as taught at schools is outdated, says that …

> "… the high school science curriculum, as normally taught today, is a saber-tooth curriculum. Because the curriculum was established in the 19^{th} century, and although times have changed dramatically, the fundamental and sacred aspects of the 19^{th} century science curriculum remain with us today".

In his amusing and satirical parable of the Saber-Tooth Curriculum, Harold Benjamin has brought up some very important issues for those who are involved in the design and implementation of school curriculum. The relevance of the Saber-Tooth curriculum at the time it was designed and launched cannot be under-estimated. It surely provided the Saber-Tooth community with survival solutions - securing food through the catching of fish, clubbing of tiny horses to death and scaring away of saber-tooth tigers from the community. However, all these conditions changed as the movement of ice from the north encroached on the community. Suddenly it became impossible to catch fish with bare hands, there were no more tiny horses to club to death, and the tiger problem ceased to exist. However, the school curriculum continued to teach all these skills irrespective of the fact that changing conditions made them irrelevant.

The same can be said for our previous content-driven curriculum in South Africa, which has been replaced by the new National Curriculum Statement (NCS), as Aikenhead (1994) has indicated above. Jegede (1994, p. 122) further argues that "… Science teaching has remained largely restricted to giving information (facts) rather than encouraging critical and creative thinking and personal construction of knowledge". Teaching has largely failed to consider the socio-cultural environment of the learner. Although the old curriculum was launched in the mid 20^{th} century, it was still in operation almost half a century later. This curriculum viewed Science as a purely rational, systematic and objective branch of knowledge which is absolute (Aikenhead, 1994). Further, the process of teaching and learning of such a 'type' of Science is that the teacher takes a central position and the learners respond by passively receiving the information. Thus the teacher takes a position of authority and the learners are simply recipients of the knowledge transmitted to them. . Although this type of curriculum and its associated pedagogical styles have had huge successes in many areas in the development of Science, its inability to assist communities to deal with social issues that are scientifically related, especially those that are environmental in nature, remains a challenge. It is at this level that the type of Science taught and the way it is taught in our schools become irrelevant, just like the Saber- Tooth Curriculum. This is what I refer to as the traditional curriculum.

The nature of Science and the way it has been taught in our schools throughout the years has brought with it many negative effects. Research has shown that there has been a sharp decline over the years in the number of students pursuing Science-related careers and/or enrolling in Science at high school level, especially girls - the nature of the teaching carried an embedded bias towards male students (Aikenhead, 1994; Yager, 1992; Lubben, Bennet, Horgath, and Robinson, 2005; Solomon, 1991). The reasons for these undesirable consequences were found to stem from the irrelevant and boring nature of the Science curriculum and the manner in which it was taught. All these point to an obvious conclusion. There is a need to improve learner interest in doing Science and the way to do this is to change the current curriculum and to minimize the use of the traditional teaching approach, which is associated with the undoubtedly outdated curriculum of the 20^{th} century. A more modern method of teaching will allow for increased learner participation in the process of learning. The study also intends to interrogate whether a teaching method, namely the context-based teaching methodology, rooted within an STS approach to the teaching of Science, may or may not assist in reversing the negative impact that the outdated Science curriculum of the 1950s brought into Science teaching and learning.

2.1.2 STS as an appropriate teaching approach for Science in the new millennium

There are a number of definitions of the STS approach to teaching. The most commonly used definition, and to me the most clearly stated, is the one by Aikenhead, as quoted by Lubben et al. (2005). It defines STS approaches to the teaching and learning of Science as …

> "… those which emphasize links between science, technology and society by means of emphasizing one or more of the following: a technological artifact; process of expertise; the interactions between technology and society; a societal issue related to science or technology; social science content that sheds light on a societal issue related to science and technology; and a philosophical, historical, or social issue within the scientific or technological community" (Bennett, 2005, p.10).

An STS approach to the teaching of Science provides a different dimension for the style of teaching of science concepts in the classroom. Whilst the increasingly irrelevant previous Science curriculum emphasized the introduction of science concepts first, followed by examples which may contain some aspects of the application of Science in industries, the STS approach begins with issues in society and uses them to build towards the attainment of science concepts (Holbrook, 1992). Bennett (2005, p. 2) says that:

> "… context-based approaches are approaches adopted in science teaching where contexts and applications of science are used as the starting point for the development of scientific ideas. This contrasts with more traditional approaches, that cover scientific ideas first, before looking at applications".

In my opinion, many conservative curriculum designers in Science would argue that this type of approach to the teaching of Science underlines the need for conceptual understanding. However, studies have shown that learning is made more meaningful if it is based on and starts from the everyday experiences of those involved in learning (Ramsden, 1994).

Context-based teaching lends itself to many, but not all, of the phases of STS approaches to the teaching of Science as shown in Aikenhead's definition quoted above. One that clearly emerges is the use of social issues related to Science in the teaching of science concepts in the classroom. One way of doing this would be to identify a social issue:

> "… which is arresting, rich in 'human interest', capable of stimulating discussion and debate, and compact in terms of its science content. It should be a concise envelope of 'situated knowledge' which are combinations of relevant scientific matter, issues of social import and memorable circumstances" (Alsop, de Silva, Watts and Zylbersztajn, 1997, p.56).

When this approach to the teaching of Science is implemented, and where the starting point is an everyday experience, issues on contextualization are catered for and serve as a means to stimulate learners' interest (Ramsden, 1994).

It is worth acknowledging that context is also used in the traditional approach. However, whilst context is often used as a means to clarify, and explain certain scientific concepts or show how Science is applied in everyday life in a traditional approach (Kasanda et al.), it is used as a starting point within the context-based approach. This starting point is often an issue in a community or society at large and therefore has the potential to elicit interest in learners. .

Aikenhead (1994, p. 3) says that in some research it was found that "concrete connections between the academic science content and the student's everyday world made the academic science more interesting to learn for 80% of the students, compared to 8% who found simulations of little or no value".

However, controversial issues revolve around the STS approach to the teaching of Science. One is the issue of whether the increase in the level of scientific literacy in communities can be attributed to an STS teaching approach or informal learning by members of communities from media such as newspapers and television, just to mention a few (Aikenhead, 1994). The same can be said for learner motivation and increased interest among learners in doing Science. I acknowledge that what learners come across as scientifically related information in the mass media may have a hand in igniting learner interest in doing Science. However, I think that a significant number of learners have been motivated and have developed an interest in doing Science, as in the situation highlighted by Aikenhead above. In a classroom where the educator uses an STS approach it is highly possible that the STS approach is the main contributing factor responsible for such changes in learner attitudes towards the learning of Science.

2.2 Theoretical Framework

I wish to explain clearly at this stage that, as a researcher, I fully subscribe to constructivist theories of learning and their implications for pedagogy. I believe that knowledge is a personal construction of ideas by individuals who are involved in learning and that the duty of those who are teaching is to guide, stimulate an interest in learning, and facilitate the process of learning. In this chapter I present and discuss three major theories of learning which inform this study. The theories discussed within the philosophy of constructivism are the ***cognitive, socio-cultural*** and ***situated learning theories***. This section also looks at how the theoretical ideas on teaching and learning, as presented in the previously mentioned theories, may be implemented in a classroom situation. The section does this by presenting classroom dynamics in the form of teacher moves, and learner engagement in the form of group work. An adapted ***classroom-level indicators of pedagogic practice*** by Bernstein was used to guide ourselves (the educator and myself) in ensuring that the lessons were, in the best possible way, learner-centred as required by the context-based approach to teaching (see Table 1). This section on the theoretical framework begins by briefly discussing the traditional nature of Science and its implications for pedagogy. Although the issue of the traditional approach to teaching has also been discussed earlier in this chapter, the discussion that follows sheds more light on what I refer to as the traditional approach to teaching.

2.2.1 The traditional nature of Science and its implications for teaching

Traditionally, Science is viewed as a body of facts entailing knowledge that is unproblematic (Carr et al. 1994). It is "portrayed and approached as a set of unchanging facts, laws and theories that, part by part, constitute the way of understanding the whole of nature and the natural world" (Kozoll and Osborne, 2004, p. 174). This perspective on the nature of Science has far reaching implications for the approach to teaching and learning in the classroom. The teacher assumes the position of an expert who owns the knowledge whilst the learner becomes a recipient vessel for knowledge. The primary duty of the teacher is to ensure successful transmission of the science knowledge to the recipients/vessels (the learners). Learners are passively involved in the learning as the teacher deliberately avoids discussions and interactions in the classroom (Carr et al., 1994).

This perspective on the nature of Science and its consequent pedagogical approach to the teaching of Science has no room in the new curriculum in South Africa. The new curriculum advocates a "learner-centred and activity-based approach to education" (RNCS Grades R-9, 2002, p. 1). If teachers are to effectively implement the new curriculum in their teaching of Science, the challenge will be to shift from the traditional teaching style of teaching to a new one that allows for more classroom discussion and teacher-learner interaction, with the learners doing most of the tasks as they take responsibility for their own learning. These new teaching approaches, which include the context-based method, are constructive in nature and are based on the learning theories that are discussed later in this chapter. In terms of these perspectives on teaching and learning, Science ceases to be a body of "facts to be mastered but rather a systematic way of building models about phenomena … models which are flexible and change based on the kinds of observations that are made" (Herrenkohl and Guerra, 1998, p. 436).

In the new Physical Sciences curriculum (NCS), the three Science learning outcomes seek to help learners develop appropriate cognitive structures to enhance the development of both scientific thinking and interest in Science. A scrutiny of the Science learning outcomes, as outlined in the National Curriculum Statement (RNCS, 2002, NCS, 2003) for both GET and FET in South Africa, reveals very explicitly the intentions of the curriculum designers. The three learning outcomes are: (1) S*cientific inquiry and problem-solving skills,* (2) *Constructing and applying scientific knowledge* and (3) *The nature of Science and its relationship to technology, society and the environment*.

A critical look at the above learning outcomes in the Physical Sciences learning area calls for a teaching strategy in Science that can promote ‘inquiry learning’ and assist learners in developing problem-solving skills, guide learners in the process of constructing scientific knowledge and how to apply it (supposedly) in the workplace and in their everyday lives, and to understand the relationship of Science to technology, society and the environment. A context-based method of teaching has the potential to cater for all three learning outcomes in Science. However, it seems to lend itself more naturally to learning outcome number three. It is mainly through this learning outcome that the relevance of the new curriculum in Physical Sciences is ensured. Educators are thus encouraged to contextualize teaching and learning by preparing lessons, as far as possible, that deal directly with societal and environmental issues.

At this point, it becomes imperative to ask the following crucial questions: What pedagogical responsiveness, as Brodie (2004) calls it, is appropriate to realize the intentions of the new curriculum in a science classroom that includes contextualization of lessons?; What implications would such pedagogical responsiveness have on teacher and learner roles and their relationship in a classroom?; If classroom discussions and the interaction between the teacher and the learners are to be encouraged, will it become necessary to create specific participative structures in the classroom?; What impact will all these have on learner interest and attitudes to doing and learning Science?

These questions lead us to a point where a discussion of the three major constructivist learning theories and their implications for the classroom practices of both teacher and learners becomes necessary. The discussion will also include a brief look at the roles of educators and learners. This will be done by looking at teacher moves and the role of group work as encouraged by a context-based approach to Science teaching.

2.2.2 Teaching and learning in Science as seen through the theories of constructivism

This section focuses on the discussion of the three main learning theories, namely the cognitive, socio-cultural, and the situated learning perspectives and their implications for teaching and learning in Science. Attempts are made to locate the context-based teaching methodology in the three learning perspectives in order to illustrate its constructivist nature.

Firstly, a brief outline of each of the theories is done followed by a thorough look at its implications for the teaching of Science. Secondly, and lastly, a comparison of the three theories is made in which differences and similarities among them are outlined. At this point the link between the context-based teaching methodology and the constructivist theories of learning is made.

2.2.2.1 The Cognitive Learning Theory

Jean Piaget is hailed as the father of the cognitive perspective on learning. Central to the cognitive perspective on learning is the notion that ***development*** precedes ***learning***. Piaget (1964) explains development as that biological process necessary for the development of the nervous system which is in turn fundamental to the development of the mental functions. The development of these mental functions leads to the establishment of the necessary mental structures that should be in place to allow learning to take place. Thus the ability of an individual to make sense of the world around him/her is dependent on the availability of the mental structures. Development is therefore a "process which concerns the totality of the structures of knowledge" (Piaget, 1964, p. s8).

The fact that Piaget's definition of development is tightly linked to the biological development of human beings, means that it becomes necessary to provide a brief description of these developmental stages in an attempt to explain how and when the mental structures are developed. It is also vital to know that these developmental stages are arrived at when the process of acquiring knowledge is seen as that ability of an individual to perform a certain operation. Hence the developmental stages are seen as biological pre-requisites consequent to the constitution and construction of mental operational structures. The first stage is the ***sensory-motor*** stage which stretches from birth to about 18 months. As Piaget argues, it is during this stage that practical knowledge essential for the substructure of 'later representational knowledge' (1964, p. s9) is developed. The second stage is the ***pre-operational*** stage. At this stage a child is able to learn vital representations, such as language. However, as in the first stage, there is still no formal operation in the child's mind during this stage. The third stage is the ***operational*** stage. At this stage, a child is able to do the concrete operations of classifying, ordering as well as elementary operations using logic. Lastly, during the ***formal operational*** stage a child's operational structures are fully developed. A child is then able to make hypotheses and even undertake abstract reasoning.

The development from one stage to the next in cognitive structures is influenced by the following factors: maturation, experience, social transmission and equilibration (Piaget, 1964, p. 10). These factors are to be satisfied every time there is a transition from one cognitive structure to the next. It will not be necessary for me to give a detailed explanation of what these factors are all about as it will not further the aim of this study. However, it is necessary to explain the equilibration factor as it seems to account more directly for the constructivist's nature of the Piagetian theory. The construction of mental structures during the developmental stages is consequent to the establishment of a schema in the human mind. This schema is constantly disturbed during the acquisition of new ideas and when the transitions from one developmental stage to another occur. Equilibration becomes necessary at this stage when the child begins to make sense of the new ideas in comparison with the old ones. Finally, the child is able to accommodate the new ideas. For those who have reached the formal operational stage, the accommodation of these new ideas would depend on their 'plausibility, intelligibility and fruitfulness' (Carr, Barker, Bell, Biddulph, Jones, Kirkwood, Pearson and Symington, 1994, p. 150). The notion of equilibration, a psychological process which occurs in an individual learner's mind, is so vital to the acquisition of knowledge that its implications for how learners learn cannot be ignored (Piaget, 1964).

Implications of the Cognitive Perspective for the Teaching of Science

The cognitive perspective on learning, like the other two that I will discuss later in this essay, has far reaching pedagogical implications. In the first place, the cognitive perspective assumes that "learning trails behind development" (Vygotsky, 1978, p. 80). It claims that no learning can enhance cognitive development as this is an independent biological process: "Learning is considered a purely external process that is not actively involved in development. It merely utilizes the achievement of development rather than providing an impetus for modifying its course" (Vygotsky, 1978, p. 79). These assertions dictate that curriculum developers have to take into consideration the level of cognitive development of learners of a specific age group (which is always related to a grade level). To support this claim, Piaget (1964) asserts that it is not possible to teach higher Mathematics to a five-year-old because s/he does not have the required mental structures in place to enable him/her to understand and make meaning of such mathematical concepts.

This notion has, without any doubt, shaped the Science curriculum where Science in the lower grades (intermediate and senior phase) is characterized by the teaching of concepts that are of a more concrete nature whilst more abstract concepts seem to be reserved for those learners in the higher grades (FET phase); this statement is based on the assumption that learners would have developed the necessary structures by then, enabling them to comprehend and make sense of such concepts. A classic example of this could be the difference in approaches used to teach the concept of 'Acids and Bases' in Grades 7 and 8 (senior phase) and Grade 12 (FET). On the one hand, the empirical approach is used to teach this concept at senior phase level where acids are distinguished from bases as being those substances with a *sour taste*, a *rough texture* and the capacity to *turn blue litmus red*. The bases are merely distinguished from acids as those substances with a *bitter taste*, *smooth texture* (soapy) and the capacity to *turn red litmus blue*. This approach is employed on the assumption that learners at this level are at the concrete operational stage. The teaching methodology has to be more concrete as well. On the other hand, a more chemical approach is used to teach the same concept at Grade 12 level. The Arrhenius and Lowry-Bronsted theories, which are completely abstract, are used to teach the concept of acids and bases. Concepts such as ionization, transfer of protons (protolysis), and acid-base conjugate pairs are all abstract. At this stage, the cognitive perspective claims that the children would have developed the necessary mental structures which will make it possible for these abstract concepts to be plausible and intelligible. This assumption is also made in the study of Grade 11-D where the average age of learners is 17. At this age, the study assumes that learners have developed appropriate mental/cognitive structures that make the understanding of scientific concepts, such as chemical reactions involving ions exchange and reduction-oxidation reactions - which dominate the section on sulphur and sulphur compounds - plausible and intelligible.

In addition, the question of age is not only looked at from a chronological point of view. The cognitive theory suggests that the mental development of children is susceptible to social factors such as the level of technological development of a society, exposure of children to cultural practices and how they are brought up. Thus the stages of mental development of children as outlined above may be delayed by a year or more.

The most striking feature of the cognitive perspective on learning is its notion of equilibration. As already explained, equilibration (or self-regulation) is said to be a psychological process which occurs in an individual's mind when new knowledge is acquired. Learning is thus viewed "as the personal construction of knowledge" (Carr, 1994, p. 149). Consequently, learners are not expected to learn and build knowledge from the same concepts in the same way. Thus misconceptions are bound to occur during any learning experience (Carr, 1994, Scott, 1994). Learners come into the classroom with their own science ideas which are in most cases contrary to expert science knowledge. It therefore becomes necessary, when a cognitive pedagogical approach such as the context-based teaching methodology, is employed, to first ascertain the learners' prior knowledge and use it as a guide in planning classroom instruction.

In the case of this study, the module developed took into consideration learners' personal experiences of coal and how it is used in their everyday lives as a source of energy. Classroom activities involved discussions on how the effects of poisonous gases, such as sulphur dioxide, can be minimized whilst using braziers for cooking and warming houses and shacks during the cold winter in Johannesburg. Another classic example of such a classroom lesson is one conducted in a school in the north of England where the natural process of rusting was used to teach chemical change (Scott, 1994). Much planning is involved in this approach to teaching. Firstly, the teacher has both to anticipate certain misconceptions that learners may bring into the classroom and also must have pedagogical techniques in place to deal with them. Secondly, the teacher must be aware of misconceptions that may arise from the lesson itself and must plan classroom activities in such a way that the potential misconceptions can be appropriately addressed. This type of pedagogical approach of cognitive constructivist theorists is referred to as *teaching for conceptual change* or *teaching for conceptual development* (Carr, 1994, Hewson, Beeth, and Thorley, 1998, Scott, 1994). Context-based teaching is one of the many constructivist teaching approaches that recognizes and allows for learners to voice their prior knowledge of specific concepts in Science; it also offers educators opportunities to solicit and deal with such ideas which are more often, as mentioned above, misconceptions.

A learner-centred approach to teaching is preferred in a cognitive constructivist's pedagogy. The traditional classroom relation of learners as recipients of knowledge and the teacher as the transmitter of expert science knowledge is challenged. Learners assume a central role in learning and classroom conversation is encouraged. This paradigm shift in the teaching of Science is viewed as a fundamental factor in teaching for conceptual change since it provides an opportunity for learners to voice their science ideas without fear.

> "If students come to lessons with ideas about their world which already make

> sense to them, then teaching needs to interact with these ideas, first by encouraging their declaration and then by promoting consideration of whether other ideas make better sense" (Carr et al. 1994, p. 150).

Embedded in this statement is the notion that meaning is negotiated. An example of how the meaning of scientific concepts can be negotiated is outlined by Carr et al. (1994), focusing on the concept of floating. Floating is a very well known natural process. Learners are bound to come to class with differing ideas of what floating is. After interacting with all the ideas of what floating could be, a more generalized explanation which covers all possible situations is arrived at.

Hewson et al. (1998) uses the notion of status to explain the process that a learner enters into as meanings of new concepts are negotiated. Using the notion of status, the process of equilibration in the child's mind involves elevating and lowering of status for different ideas. The status of an idea is judged on three aspects: intelligibility, plausibility and fruitfulness (Hewson, 1998). An idea is said to be intelligible if it makes sense to the person. It is plausible if it is consistent and reconcilable with the existing ideas in the person's schema. The fruitfulness of an idea refers to how useful this idea is to the holder in helping to solve problems that had no solutions before and which can help the holder to make predictions and draft directions for future representations. Teaching for conceptual change should aim at lowering the status of those unacceptable learner ideas (misconceptions) and encourage the raising of status of those that are conceptually correct in the world of Science.

In teaching the property of sulphur dioxide – its capacity to dissolve readily in water - it emerged that most learners in the Grade 11-D class were familiar with this concept as they made use of this knowledge practically at home on a daily basis. During discussions in the classroom, it emerged clearly that most learners kept a bowl of clean water next to the brazier every time they cooked or kept themselves warm at home. Although they did not use any scientific reasoning at the time to explain why the bowl of water had to be placed next to the brazier and not above it, they had a notion that this reduced the risk of their inhaling the poisonous gas coming out of the ‘mbaula’/brazier, as they call it. As the teacher and I explained the concept of sulphur dioxide being denser than air and therefore sinking to the bottom and dissolving readily in water, learners began to make sense of what they were practising all along and were then able to explain their actions in a more scientific manner. Thus, at this stage, learners were able to raise the status of the ideas they held unthinkingly before coming to the classroom (Hewson et al., 1998). They found themselves in harmony with the scientific reasoning and explanations offered.

A number of issues concerning the above cognitive constructivist way of planning Science lessons need to be unpacked. In the first place, multiple ways can be followed in the teaching of one specific lesson. The planning of this type of lessons takes a long time, since careful analysis of what is viewed as learner prior knowledge becomes necessary and a careful plan should be devised to ensure the achievement of the intended outcomes of the lesson. In an education system which is syllabus based, as in South Africa, this might prove to be a problem as the lengthy planning and teaching time of lessons might lead to teachers failing to complete their syllabus.

2.2.2.2 Socio-Cultural Perspective

The socio-cultural perspective is propagated by Vygotsky (1978). Vygotsky (1978) begins his learning theory by challenging the idea that development precedes learning, as advocated by Piaget. Whilst he acknowledges the fact that learning and mental development are interrelated, he argues, contrary to the claim made by cognitive constructivist theorists, that development is the consequence of learning. Children are confronted with learning experiences right from the time of birth. These learning experiences which, amongst many others, include the acquisition of language, result in the development of the mental structures that account for their readiness for school.

Central to Vygotsky’s social cultural perspective is the notion of the zone of proximal development. To understand the zone of proximal development, it is necessary to know that each learner’s mental structures are at a certain level of development when s/he enters school or comes into a specific classroom. This level of development is known as the actual level of development. The learner is able independently to deal with any activity pitched at this level with great competence. However, there are those activities that a learner may be unable to do on his/her own but can only perform under the guidance of an adult or through working in groups with capable peers. The difference between these two levels of competencies is known as the *zone of proximal development.*

> " … the zone of proximal development … is the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978, p.86).

The socio-cultural perspective suggests that progressive learning is only possible if it occurs within the zone of proximal development of the children. There are two main aspects to the zone of proximal development. Firstly, it poses a great challenge for Science and other teachers in general. In order to offer appropriate guidance to the learner, the teacher (as the adult in the learning process) has to be an expert in his field. Secondly, the interaction of learners in class in groups is to be encouraged because less competent learners will be able to learn from their more competent peers. Learning in this perspective is therefore viewed as a collective and collaborative effort. The role of the teacher becomes that of a facilitator. The teacher has to devise strategies that will help him ascertain the actual development of the child and use it to develop instruction that will help the learner to achieve those prospective competencies (Hedegaard, 1990).

The cognitive perspective and the socio-cultural perspective do share some common aspects. One obvious commonality is that they are both constructivist theories. They both acknowledge that learners have prior knowledge and construct or build knowledge based on their existing knowledge. However, these two theories differ sharply on the psychological aspect of how knowledge is constructed. In the cognitive perspective, the learner individually constructs knowledge and this is only possible if the mental structures are fully developed biologically. On the other hand, the socio-cultural perspective suggests that internal developmental processes are stimulated by learning and that learning occurs "when the child interacts with people in his environment and in co-operation with his peers" (Vygotsky, 1978, p. 90). Thus, whilst knowledge is individually and mentally constructed within the cognitive perspective, it is seen to be socially constructed within the socio-cultural perspective. Learning is seen to be an individual effort within the cognitive perspective whilst it is viewed as a collective/collaborative effort within the socio-cultural perspective.

2.2.2.3 Situated Learning Perspective

The situated learning perspective is based on the notion that learning occurs only when learners actively participate in communities of practice (Lave, 1996; Hanks, 1991; Brown, Collins, and Duguid, 1989). "It takes as its focus the relationship between learning and the social situations in which it occurs" (Hanks, 1991, p. 14). The process of learning is termed the legitimate peripheral participation (LPP) and the learners involved are thus referred to as legitimate peripheral participants. Those who are experts in a particular field of practice are called masters. Children are the legitimate peripheral participants as they engage in practices that help them acquire the ability to speak the language in their community whilst the adults in the community play the role of the masters (Lave, 1996). It is this notion of legitimate peripheral participation (within a community of practice) that significantly distinguishes the situated learning perspective from the cognitive and the socio-cultural perspectives described above.

Unlike the cognitive perspective where it is "the individual mind that acquires mastery over processes of reasoning and description, by internalizing and manipulating structures, … learning is a process that takes place in a participation framework, not in an individual's mind" (Hanks, 1991, p. 15). The construction of knowledge is determined by the contexts in which the participants are actively engaged and not by the maturation of some mental structures as claimed by the cognitive and socio-cultural perspectives. It is also of great importance to mention that, although the cognitive and socio-cultural perspectives agree that there is development of mental structures in the mind of an individual, their differing positions on what comes first between learning and development leads to a different explanation of how this psychological process occurs.

Central to the notion of LLP in situated learning is the idea that participants are geared towards meaningful learning since they are engaged in what is labeled authentic activities. The participant (also known as the apprentice) and his/her fellow apprentices are co-participants in a community of practice with the masters (experts in the activity). Take the example of children learning the language of their community as cited above. The activity they engage in as they learn the language is authentic since the process of learning involves the assumption of those actual roles of the children being the apprentices and the adults being the masters. “Authentic activities then, are most simply defined as the ordinary practices of the culture” (Brown et al. 1989, p. 34). In the light of authentic activities, the process of learning is therefore seen as the enculturation of the apprentices into the culture of the community of practice in situated learning. An example of a community of practice could be a community of scientists, mathematicians, historians, etc. A striking difference on how the socio-cultural and the situated perspectives view classroom activities is that for the socio-cultural, imitating the real activities, assuming they are those of the communities of practice, in classrooms is enough for children to learn whilst for the situated learning perspective, the activities have to be authentic.

The idea of collaborative effort in learning, which is evident in the situated learning perspective, is also encouraged by socio-cultural theorists such as Vygotsky (1978). They hold that children learn better when they receive assistance from others who could be their peers or who are more competent in performing the activities or adults who, in situated learning terms, are referred to as the masters or experts. However, there are underlying differences between the two theories when the focus is placed on the level of participation of the learner in the activities. In the socio-cultural perspective, the learner’s acquisition of knowledge is determined by his/her ability to perform a complete operation/activity under the guidance of capable peers or adults. Contrary to this notion, the learner (participant) in situated learning does not have to perform the complete task, but assumes a role as s/he participates in a practice. To master the skill, the participant may only change roles over a period of time. It can also be argued that the notion of ZPD in the socio-cultural perspective and the quest for the mastery of a skill by a legitimate peripheral participant in order to become the master in a community of practice pose similar cognitive challenges for a learner. Thus the ZPD, as outlined by Vygotsky, for a newcomer in a community of practice, might be the 'distance' between what s/he is able to do as s/he enters the apprenticeship and what the masters are capable of doing.

As in the socio-cultural perspective, one explicit implication of situated learning for Science teachers is that they should constantly strive to be experts (masters) in their field. The authentic activities of the scientists have to be practised in the classroom. However, Bowen (2005) argues that care has to be taken when the traditional classroom culture is to be replaced by the 'authentic' Science one. Fundamental to this will be the importation into the classroom of those competencies in the Science practices of professional communities. The school culture, therefore, has to be drastically changed to accommodate the execution of authentic activities. The learner must be afforded the opportunity to learn from peers and from the teacher as the master. Teachers are also active participants in learning as they play their mastery role.

2.2.2.4 Teaching and learning Science in a constructivist perspective

It is not easy to show how Science can be taught in class using the cognitive and the situated learning perspectives (socio-cultural perspective included) because "they do not directly lead to a particular pedagogical approach" (Brodie, 2005, p. 27). However, applying these theories in the teaching and learning of Science can enhance the ability of learners to think scientifically. Thinking scientifically includes being able to hypothesize, predict, apply science knowledge and concepts in solving problems, communicate science ideas, interpret information and raise questions about situations (RNCS, 2002). Herrenkohl and Guerra (1989) quote the argument by Kuhn and Duschl which, in a very general way, says that "thinking scientifically means understanding the nature of scientific knowledge and the tolls and processes that characterize scientific discussions" (p. 436). This part of the chapter investigates some theoretical classroom practices as informed by the theories discussed above in order to display some of the classroom techniques that could be useful when using context-based teaching methodology in the science classroom. These classroom practices were purposefully used in the classroom to examine their efficiency in drawing the interest of learners both into doing Science in the classroom and also stimulating their engagement in classroom activities.

Using Group work

In group work, the teacher plays an important role in creating a stimulating environment in which learners are free to voice their views on science concepts and in the process, without their even knowing, they take responsibility for "generating, supporting, and building knowledge and understanding through their engagement in classroom activities" (Herrenkohl and Guerra, 1998, p. 432). This statement supports the view that cuts across the three learning theories discussed above, that knowledge is constructed rather than transmitted. All the three theories on learning see group work as a powerful tool that provides learners with an opportunity to construct knowledge when used purposefully in the teaching and learning of Science. "For cognitive perspectives the group is a social influence on the individual; for situative perspectives the group is the important unit, which produces mathematical *(Science)* ideas beyond the individual ideas" (Brodie, 2005, p. 27). For socio-cultural perspectives the group is a support base where the learners constantly receive assistance from the more capable peers or the teacher to fully develop science ideas. As Brodie (2005) indicates, one or all of these purposes of group work might be working in a classroom at any given time. Group work offers an opportunity for learners to freely and openly contribute to the process of learning in class. Through these learner contributions the teacher is able to ascertain the level of scientific thinking that the learners have achieved. Brodie (2005) confirms this notion by stating that "the only window that teachers and researchers have into learners' thinking is through what learners say and do in class, i.e. their contributions" (p. 36). The success of teachers of Science in helping learners develop an interest in doing Science and also assisting them in developing science thinking patterns is only evident in what learners do and how they engage in activities that require them to apply and discuss science knowledge and concepts. It was mainly during the group discussions and learner feedback in the form of presentations that the level of enthusiasm and the will to learn was observed during the study. A journal was carefully kept in order to capture classroom interactions, both amongst learners and between the learners and the teacher(s).

Learner contributions always reflect what they think or comprehend of certain science concepts. Listening to learner contributions during discussions in class and carefully checking on handwritten responses to science questions enabled us to pick up the level of enthusiasm and interest that learners displayed during the study. The teacher and I had a duty to correct the misconceptions of learners concerning the use of coal (we validated correct contributions and discouraged incorrect ones).

A brief discussion of different theoretical group work approaches to the teaching and learning of Science is done below. All these group work strategies were used in the study. However, I do not wish to make any claim that these strategies were extensively employed. The study only took place over two weeks and therefore making such a claim would not be realistic. The different approaches to using group work in class are outlined by Brodie and Pournara (2005), namely, ***co-operative learning approaches, collaborative problem-solving approaches, socio-cultural oriented approaches, situated approaches*** and ***socio-political approaches***.

The co-operative approach

This group work approach encourages peer teaching. Learners are given the responsibility to teach each other and ensure that all members of a group understand what is being taught. Responsibilities are delegated to members of the group, e.g. group leader, scribe, reporter and time keeper. It focuses mainly on the mastery of content and clarification of concepts and offers very little room, if any, for heated classroom discussions of science ideas. This perspective on group work suggests that "learning consists of acquisition of skills and content by individuals; therefore individual testing and the evaluation of learning outcomes at an individual level are seen to be important" (Brodie and Pournara, 2005, p. 37). This assertion seems to support the claim by cognitive theorists that knowledge is individually constructed and therefore it must be individually assessed. Teachers who find value in using this approach to group work, usually use the Initiate-Response-Evaluate (IRE) method of assessment, both verbally and through written worksheets, where the teacher mostly asks only those questions to which s/he already has answers. Herrenkohl and Guerra (1998) argue that this type of questioning does not assist learners to build knowledge on what they already know but only serves to test what they already understand. Certainly, this type of group work does very little, if nothing at all, to assist learners develop science thinking skills. However, this group work strategy was used in the study because of the potential it has to raise the morale and confidence of learners in working together to find solutions to simple science problems. Learners discussed and listed the constituents of coal and were asked to use chemical equations to show how these constituents burn oxygen to form their respective products. Learners were given roles such as those of scribe and group leaders.

Collaborative approach

This group work approach is used in "situations where the learners interact on a task that none would be able to solve alone" (Brodie and Pournara, 2005, p. 39). During the interaction, it is believed, learners create areas of conflict and as they engage in debates about which ideas are most appropriate, conceptual growth is achieved. The strength in this learning approach is that it is able to create the necessary dialogue amongst students which certainly enhances their intellectual capacity. However, there is no guarantee that learners may always come up with scientifically correct resolutions to their cognitive conflicts. This group work strategy was applied in the study. A task was posed. The groups had to discuss and come up with a solution to the problem - the ill effects of burning coal in their area. Solutions were to be presented as groups to the whole class and discussions were taken from there. Ideas, such as electricity for all, emerged strongly in the debate. However, it was amazing to see how extensively the knowledge that some learners had about how electricity is generated using coal and how the idea of 'electricity for all' had to be rejected as solutions to the problem.

Socio-cultural approach

This approach to group work is based on Vygotsky's theory of learning. In this perspective learning occurs within the zone of proximal development. The teacher creates the zone of proximal development by introducing learners to science activities that are beyond their actual level of development. The teacher, together with those learners knowledgeable enough to assume the role of capable peers, assists the rest of the class in successfully completing the tasks at hand. However, since the teacher cannot be with all the groups at the same time, it is likely that 'capable' peers may use ideas that are scientifically incorrect. The teacher is, therefore, advised to make constructive interventions to bring in the Science voice (Brodie and Pournara, 2005). Whole class discussions may be necessary. This group work technique was also used in the study. It was conducted through learner worksheets based on reduction-oxidation reactions (redox). Learners were expected to show how net ionic chemical equations are arrived at from redox half-reactions. It was very interesting to see how learners engaged in the activity and assisted each other throughout the tasks. Debates around why certain ions could not be shown on the final (net) ionic equation were very hot, and an intervention by educators assisted in resolving the issue by introduction of the concept of *spectator ions*.

Socio-political approach

This approach to group work is aimed at bringing about equity in a science classroom. This is arguably not a pedagogical approach to group work but a social arrangement of learners in groups that bridge the stereotypes of race, gender, class, language and scientific competencies. This idea was used in the study. However, it was not used to deal with issues of race as only African learners attend the school, but was done mainly for ethical reasons, i.e. bridging the gap between those learners who live in the informal settlement without access to electricity and those who come from the local township. This was necessary as the use of coal occurs mainly in the informal settlement and this could have easily put the learners from the informal settlement under the spotlight as perpetrators of the problems associated with the burning of coal in that community. Ten groups of five were formed randomly by counts of five to ensure that each group contained members from both of the social groups – learners from the informal settlement and those from the local township.

Situated approach

This approach to group work in class is based on the situated perspective on learning. This perspective sees learning Science as a process of participating in scientific activities. The teacher plays the role of a master who organizes scientific activities with the purpose of achieving different kinds of learning. Learners work together and assist each other through working on the activities. The teacher intervenes to provide access to these science activities (practices) (Brodie and Pournara, 2005). This type of group is seen as a gateway to helping learners develop identities as science learners and of self in relation to the subject. To be specific, the type of identity which is most likely to be developed is one that Gee (2001) will call affinity identity or A-identity. This is an identity developed by learners owing to their membership of a community of practice. This type of group work technique was used during the performance of an experiment. Different working stations were set up in the classroom for groups to rotate and perform experiments. The experiments involved taking water audits by checking whether it was good for consumption or not, and finding exactly what the chemicals in the water were, showing the solubility of sulphur dioxide in water, checking the effects of sulphur dioxide and hydrogen sulphide on solutions of iron (III) sulphate, potassium dichromate and potassium permanganate.

Teacher Moves

Teacher moves are of great importance in encouraging constructive learner-teacher and learner-learner interactions in a science classroom. Teacher moves refers to actual practices in the classroom that the teacher embarks on or uses to coherently and deliberately guide, stimulate interest and even foster learner contributions. Through the use of language in the classroom, the teacher may, using what Brodie (2004) calls level 1 codes, *confirm*, *direct*, *initiate* and also make *follow ups* on learner contributions. On level 2 codes, the teacher may *confirm*, *maintain*, *press* or *elicit* learner ideas and also *insert* his/her own ideas when necessary. Serious attempts were made by the teacher and the researcher to use this kind of code in the classroom so as to ensure that the lessons were learner-centred. Brodie (2004) designed this coding system to analyze teacher practice in class. This coding system, together with Bernstein's as outlined in the table below, were used to check the degree of learner-centredness of our lessons during the study and how effective we were in stimulating learner interest in participating in classroom activities. The following table is an adaptation of Bernstein's classroom level indicators of pedagogic practice without the scoring section as outlined in Taylor et al. (2003).

Table 1 Bernstein's adapted classroom-level indicators of pedagogic practice.

Classroom-level Indicators of pedagogic Practice	
Theoretical Subconstruct	**Indicator**
Social Relations	1. How open are relations among pupils? 2. How open is the relationship between the teacher and the pupils?
Proficiency in the Language of Instruction	2. How proficient is the teacher in the language of instruction? 3. Are explicit attempts made to promote development of the language of instruction?
Macro level pacing – planning, coverage and sequencing	4. Is there evidence that the teacher has planned the lesson under observation, with sufficient detail to show: • Knowledge content • Class activities • Homework (if applicable)?
Micro-level pacing	5. Is the teacher ascertaining at what level the learners are, and engaging them at that level?
Cognitive Demand	6. Is the knowledge object of the lesson clear?
Explication of evaluation criteria	7. To what extent does the teacher: • Ask leading questions so as to draw conceptual principles? • Give feedback to learners' questions, and verbal and written answers, authorizing correct answers and correcting misconceptions and gaps? • Ensure that the knowledge principles from the activities are clearly and explicitly stated?

2.3 Chapter Summary

In this chapter I have attempted to link the science learning approach and curriculum to learning theories, namely: cognitive, socio-cultural and situated. I have also made an effort to link science learning to pedagogy. A discussion centring on teacher practices in the classroom is also done in this chapter to illustrate the various ways in which science educators may make teaching learner-centred.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.1 Research Design

An interpretive methodological framework was adopted for this study. The study was interpretive as it involved an in-depth interpretation of learner interviews, observations and answers to questionnaires (Stears, 2006). The ontology, epistemology and methodology that characterize an interpretive study respectively are that "(1) peoples' subjective experiences are real and should be taken seriously (2) we can understand other's experiences by interacting with them and listening to what they tell us and (3) that qualitative research techniques are best suited to this task" (Terre Blanche and Kelly; 2002, p. 123). Although attempts are made to present data numerically at several stages in the study, the study is qualitative in nature rather than quantitative. Leedy (1997) argues that data speak more clearly and forcefully, ensuring that a better understanding of their nature and interrelations is achieved when qualitative methods in research are used. Hughes and Hitchcock (1989) contend that qualitative research provides rich data which assists in maximizing understanding of events as well as facilitating interpretation. .

In this study, a questionnaire (see Appendix B), a test (see Appendix F), classroom observation and interviews (see Appendix D) with learners were used to collect data. The educator was also interviewed (see Appendix E) at the end of the study to check on the kind of difficulties that he may have identified, associated with the use of a context-based approach to the teaching of Science. Learner performance in the test given at the end of the intervention was analyzed and compared to the learner performance in the test given by the educator on the same section of work just before the intervention. This was done in an attempt to answer one of the research questions on whether the use of a context-based approach to the teaching of Science could improve learner performance.

The questionnaire was administered at the beginning of the intervention to establish the attitudes of learners to doing Science and the level of interest. The questionnaire and the interview questions were piloted in February, four months before the study was conducted, in order to refine them to ensure that the responses are relevant and realistic. The piloting was done at the same school where the study was conducted using a group of learners from another Grade 11 class who did not form part of the focus group, Grade 11-D. Breakwell (1995) and Opie (2004) see the process of piloting data gathering instruments such as questionnaires and interview schedules as an important component of research.

Classroom observation was continuously done during the intervention to document any changes in the behaviour of learners as they engaged in a science lesson based on the Sulphur and Sulphur Compounds module. The classroom observation was ethnographic in nature as it was not based on predetermined classification of behaviour as is the case with systematic classroom observation (Mbano, 2002). (It was also not necessary to have a structured observation schedule as there was no need to eliminate differences in data collected as I was the only researcher engaged in data collection.) Classroom observation focused on classroom events depicting the social-cultural interactions which were used to inform the level of learner interest as they engaged in the lesson during learner activities (whole class discussions, group discussions and presentations). Groups that were enthusiastic and non-enthusiastic during discussions were respectively classified as ***Highly motivated*** and ***Poorly motivated***. This was done to check whether the use of a context-based approach to the teaching of Science assisted in developing learner interest and/or positive attitudes towards the learning of Science. As is the case with ethnographic classroom observations, the data was collected in the form of field notes.

The interviews for both learners and the teacher were done at the end of the intervention. This was done to check on the validity and reliability of the data collected during classroom observation in the form of field notes by way of correlating. Opie (2004) believes that interviews can be used to procure clarity on some of the collected data that may have been somehow unclear. It must be noted at this point that, as the study was not experimental but interpretive in nature, the use of questionnaires administered initially was not necessary at the end of the study.

3.2 Data Collection Techniques

In terms of data collection, the study consisted of four stages. The four stages were:

A. Administration of the questionnaire
B. Classroom observation during teaching and learning
C. Administration of the tests (pre and post)
D. Learner and teacher interviews.

The initial stage involved the administration of a questionnaire. This was done before any intervention took place. All Grade 11-D learners filled in the questionnaires at the same time. Learners were not allowed to share any ideas whilst answering the questions in order to ensure the authenticity of their responses. The completed questionnaires were then collected by the researcher for safe keeping before they were analyzed. Questionnaires are effective ways of gathering data for research purposes (Opie, 2004). Apart from being a reliable and valid method of collecting data, questionnaires were used because they are economical, allow for standardization of questions and guarantee anonymity of respondents (Opie, 2004). The questionnaires consisted of two sections. Section A comprised close-ended questions whilst section B comprised open-ended questions. As this study is qualitative in nature (Hatch, 2002), it was necessary for me to include open-ended questions to encourage the respondents to voice and explain their perspectives, opinions and feelings. Close-ended questions are viewed as limiting when it comes to responses because they only allow for given answers such as yes or no, or are based on a Likert scale which only allows for a choice from a particular set of answers as pre-determined by the researcher (Bailey, 1994; Opie, 2004). Furthermore, it is also found that respondents seem to be more comfortable in answering questions that allow them to voice their feelings about issues than choosing answers from a given set (Bailey, 1994).

Secondly, classroom observation was used to collect data. According to Terre Blanche and Kelly (1999), observation is the second most popular way of collecting data in an interpretive research approach. It offers the capacity to bring the researcher close to what actually happens when people in a particular setting interact with each other. The observation was unstructured. Data was captured by the researcher in the form of field notes. The observation was mainly done during group work in the classroom while learners engaged in tasks given in the module.

Thirdly, a ***summative test*** was written by learners at the end of the intervention. Learner performance in the given test was checked against their performance in a previous test prior to the intervention. This assisted in answering the research question based on whether context-based teaching in Science can improve learner performance. The use of tests as assessment tools based on traditional science content only, without any assessment based on STS content, may be problematic for STS scholars. Aikenhead (1994) indicates that teaching Science the STS way can be categorized into levels based on a traditional science syllabus or “according to a natural sequence suggested by the STS content itself” (p. 54). On an eight category sequence as suggested by Aikenhead (1994), this study lends itself to category number two, dubbed **Casual Infusion of STS Content**. At this level, teaching Science the STS way is organized according to a traditional science syllabus but includes a short study of STS content of about ½ to 2 hours in length. The module used as an intervention in teaching learners in this study comprised about three hours of STS. When teaching Science at this STS level, as suggested by Aikenhead, “students are assessed mostly on pure science content and usually only superficially … on the STS content (for instance, 5% STS, 95% Science)” (p. 55). However, the study also overlapped with category one where the STS content was used solely for stimulating learners into doing Science. As mentioned earlier, Aikenhead’s categories on teaching Science the STS way run from level one to eight. Of these categories, only categories one to four are structured through the use of a traditional syllabus. Categories five to eight are those that are purely structured and driven by STS content. The STS content at these levels begins to take significant parts of the assessment tools where they would form 30% and above. Although it would be interesting to have a thorough discussion of the eight categories of the STS way of teaching as stipulated by Aikenhead, I wish to mention that this was only done to explain why a test (summative test) was used as one of the data collecting instruments. It was also convenient to use the test at the end of the intervention since one of the research questions targeted learner performance.

Lastly, ten minutes interviews were conducted with ten of the 50 Grade 11-D learners. The interviews were also unstructured. They allowed the respondents to express their feelings and views freely. Although open-ended questions are able to solicit information about views and feelings of respondents, they often fail to do so (Opie, 2004). Interviews that are less structured and are based on open-ended questions became necessary to capture fully the views and feelings of the respondents. Follow-up questions were given by the researcher wherever there was a need for more clarity. Some of the questions during the interview were deliberately linked to questions on the questionnaire and to some of the responses in order to check on their authenticity. The researcher, however, subscribes to the view given by Terre Blanche and Kelly (2004) on constructionist researchers - the meanings of statements/responses in interviews are not constructed by the interviewee alone but are jointly constructed by both the interviewee and the interviewer. The researcher in this study is therefore aware that the interpreted meanings as captured in the results jointly project the voice of the respondents and that of the researcher.

3.3 Population Research Sample

The sample used in the study consists of 50 learners, boys and girls, of Grade 11 in a school in Soweto, South Africa. The 50 learners formed one of four Grade 11 classes at the school. The school was conveniently chosen because of its geographical location. It caters for learners from the immediate township and those from an informal settlement which is only about 5 kilometres away. The use of coal as a source of energy in this area (especially in the informal settlement) is rife. This made the school a logical choice, as the central theme on which the STS module was based is the burning of coal. Furthermore, the Grade 11 class was conveniently chosen as the science content addressed in the module specifically forms part of the Grade 11 Physical Science syllabus. Kelly (2004) refers to this way of sampling as *convenience* or *opportunistic* sampling. Another factor considered in the sampling was based on the practical constraints identified by Durrheim (2004), such as time and the number of participants whom the researcher could handle. The four Grade 11 Science classes together made up about 200 learners which would have been a difficult number to handle. Durrheim (2004) also argues that typical qualitative research studies like this one "do not draw large or random samples" (p. 45). In addition, although the findings from a relatively small research sample can be transferable to other settings (Durrheim, 2004), the researcher does not intend to generalize the findings from this study.

3.4 Ethical Considerations

The importance of ethical considerations when doing research can never be over-emphasized. Durrheim and Wassenaar (1999) outline the purpose of ethical consideration as being the need to protect the welfare and the rights of those participating in the research.

Permission to conduct the study was sought from and granted by the Head of Department of the Gauteng Department of Education (GDE). How the study could help to assist science teachers in the school to improve their teaching methodologies by becoming more innovative was outlined to the Head of Department. The principal of the school where the study was conducted was consulted and made aware of the intention to conduct the study at her school long before the application for permission to do the study was sent to the GDE Head of Department. The principal also gave permission for the study to be done at her school. The sampled learners (Grade 11-D) were informed of the decision to use their class to conduct the study and the matter was discussed at length. The learners were asked to give consent by way of filling in a consent form (see Appendix A). It was also explained to them that they were under no obligation to participate and that they could at any time remove themselves from participating without fear of prejudice or victimization. Arran-gements were made for learners, who expressed the wish to remove themselves, to join the other Grade 11 science classes. The learners and the teacher were both assured that only pseudonyms would be used in place of their names when reporting. Although learners from the other classes did not benefit from the use of context-based teaching methodologies, they were provided with all the materials used in Grade 11-D during the intervention. These materials included the module, the worksheets and exposure to all the practical work done with Grade 11-D. Clearance for the study was also granted by The Ethics Committee (Non-Medical) of the University of the Witwatersrand.

3.5 Chapter Summary

This chapter outlines the research procedure followed in this study. The study is qualitative and follows an interpretive form. Although an attempt is made to present data numerically where necessary, for example when the test scores are presented, most of the data collected is qualitative in nature and the interpretation is done qualitatively.

This chapter also provides a discussion of the research techniques used in the process of gathering data. Four major techniques were used: (1) questionnaire, (2) observation, (3) test scores and (4) interviews.

Lastly, the chapter focused on the ethical considerations of doing research. A brief report is given detailing how permission to conduct this research was granted by all the necessary stakeholders. The discussion also includes how consent from the main participants in the research - the learners - was requested and granted.

CHAPTER 4

DATA ANALYSIS

4.1 Introduction

Although the study is qualitative, both the quantitative and qualitative aspects of the questionnaires were broken down into numerical levels wherever necessary and they were quantified and organized into tables and graphs in the form of pie charts and histograms. Patton (2002) agrees that, although qualitative findings may be presented alone, it is possible for both qualitative and quantitative findings to be presented together.

Responses to the open-ended section of the questionnaire led to the emergence of themes based on both learner interest and attitudes towards doing Science at school. These themes were categorized into four groups as discussed later in this chapter. The researcher constantly refers to statements that capture both the behaviour of the subjects and other events (a journal was used for this purpose).

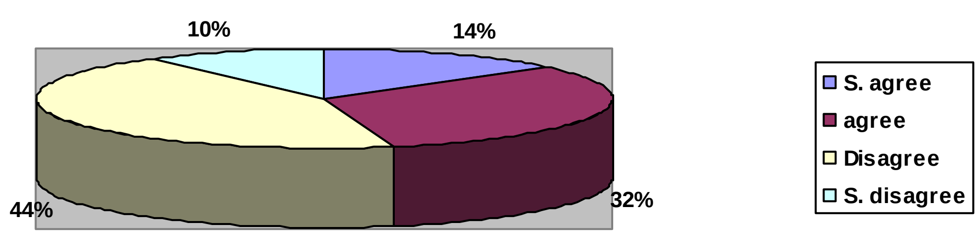
Comparative graphs on learner performance are drawn, based on the scores from a test prior to the intervention and the scores from the test based on the topic taught during the intervention. The data based on learner interviews is mainly used to explain the trend in learner performance and to ascertain their views on the use of the context-based approach to the teaching of Science.

4.2 Qualitative data based on Likert scale responses

The statements used on the questionnaire were rated through the use of a Likert scale which was categorized as follows: ***Strongly agree, agree, disagree*** and ***strongly disagree***. An in-between position such as ***neutral*** or ***not sure*** was deliberately omitted to avoid mid-point tendency. Pie-charts, based on the responses for a number of selected statements, are shown below.

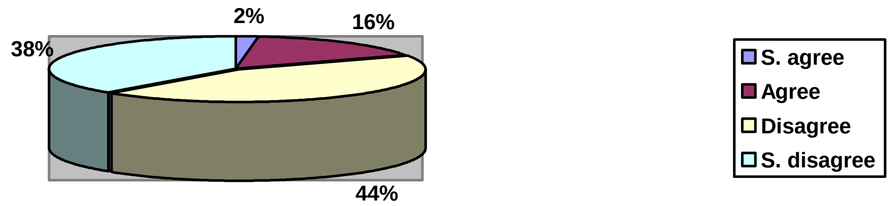
The Positive Statement: ***I like scienceScience because it's fun.***

Diagram4.2.1



The negative Statement: ***Science is the most boring subject of all at school***.

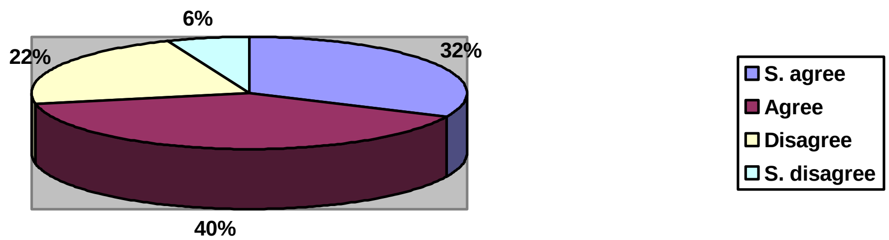
Diagram 4.2.2



Statement on learner performance

I am not pleased with the way I perform in Science. It is always poor.

Diagram 4.2.3



4.3 Qualitative data from the questionnaire

The qualitative data collected through the questionnaire, as far as learner interest in doing Science is concerned, was based mainly on two open-ended questions. The first question dealt mainly with the level of learner interest in doing Science whilst the second asked for learner opinions on how to make the learning of Science interesting. The two questions posed to learners here were:

1. ***Do you find Science interesting or not? Explain your answer.***
2. ***Tell us what you think needs to be done to make the learning of Science more interesting.***

The responses by learners to the first question varied. It then became necessary to categorise the data given by learners according to the emerging themes. The first category, which made up 10% of the learners, spoke to the benefits of doing Science, such as getting employed easily after completing Grade 12, receiving bursaries for further studies at university in order to get white collar jobs, etc rather than their level of interest in doing Science at school level. This group was labeled the ***Science Benefit Group*** (SBG). They wish to see themselves employed in science-related white collar jobs that will give them financial stability after completing their trainings as scientists, medical practitioners, engineers, etc. Responses such as the following are found in this group of learners:

> Lunga (not his real name): "*I find Science interesting because it will help me when I work, maybe the work it will need people who was doing Science… Science it is difficult but I will try to make it*."

The second category, which I refer to as the ***Social Oriented Group*** (SOG) made up 18% of the learners. This group feels that being in the science classroom at the school in question is interesting and they always enjoy being in the Science class simply for social reasons. The SOG likes to be part of the science class because during science periods they get the time to socialize more with friends as the teacher hardly keeps them occupied with work or engages them in serious learning.

> Kim (not her real name): "*Science is both interesting and boring because sometimes when I go to the Science classroom its play play play, and we don't have much work to do and it is interesting 'cause you get to talk to your friend at the Science classroom and sometimes it is not interesting because the teacher come up with difficult task for us to do and the thing is that he never taught us about that task and he would want us to give our best to the task*"

The third category is the ***Subject Content Group*** (SCG). This group made up 25% of the learners in Grade 11-D. They feel that Science itself as a subject is very interesting. The content taught helps them understand how the natural world works and through Science a many new discoveries are made. This group seems to be composed of science-minded learners who find joy in the science content.

> Kefi (not her real name): "*I do find Science interesting because it teaches me more about the world I never knew it exist (Science world). And also it makes me want to know more because of the things that the scientists discover …*"

The fourth group is the ***Quality Learning and Teaching Group*** (QLTG) which makes up 36% of the learners in 11-D. This group of learners feels that learning Science can be very interesting but needs a committed and passionate teacher who will use different teaching ways, such as the use of experiments to make Science more fun. These learners felt that the way Science is taught makes it a boring subject. They blame the teaching methodology that the teacher uses and also question his commitment and passion for teaching Science.

> Nonceba (not her real name): "*I find Science interesting eccept of couse the teacher who is so discarraiging when it comes to lessons. This reduces my spirit and confidence in Science…This makes … really bad because of the type of teaching I get from my teacher. This is really sad because it is already destroying my future*"

> Thulani (not his real name): *"… we are not getting a better teaching so I performance is look like is poor … you will find out that the learners are playing there is nothing they can do because of the teacher not around during that time*".

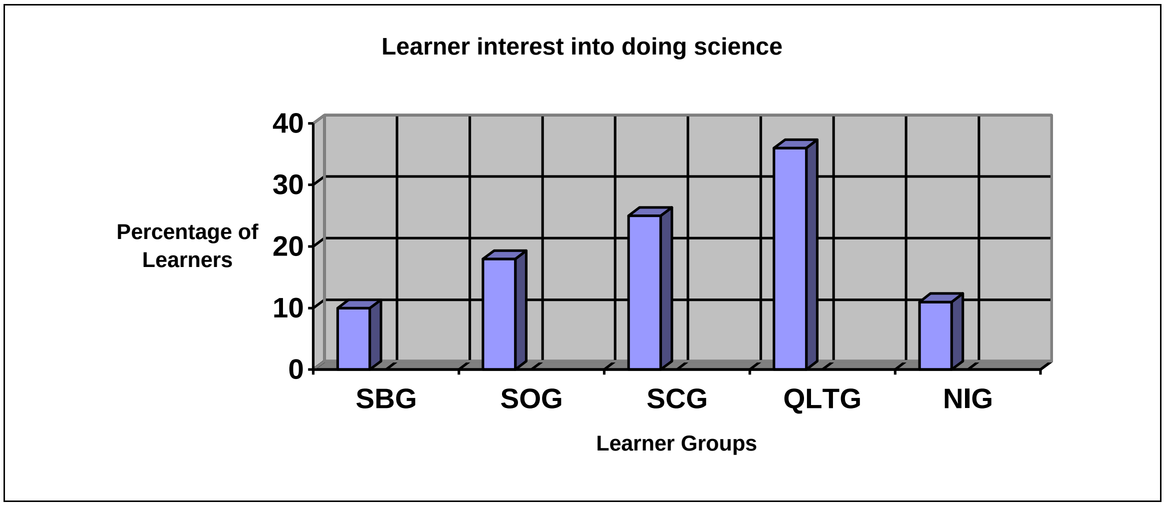
The last category comprises a group of learners who feel that there is nothing interesting in learning Science. I refer to this group as the ***Not Interested Group*** (NIG) and they form 11% of the learners in Grade 11-D. There is a strong overlap between the QLTG and the NIG. However, it was necessary to separate the two groups as new characteristics defining the latter, such as the input of girls on their performance in Science compared to that of boys, were worth noting. There are several reasons as to why this group finds

Science not at all interesting. The reasons range from poor performance in the subject to failing to understand what is taught. However, most of the concerns that these learners raise point to the way Science is taught as the main reason why they are uninterested in doing Science. They find it very difficult to understand what they are taught in Science and therefore always perform extremely poorly compared to other subjects. Some of the girl learners in this group also think that Science has a masculine nature and therefore only boys can fully participate, enjoy and achieve in the subject. They believe this explains why they do not understand what is taught in the science class and also why they are not passing the subject no matter how hard they try.

> Lettie (not her real name): "*I find Science not interesting because I don't see the benefit of doing it. Even to pass I don't pass like other subjects. Even if they teach I don't understand the teacher. My performance in Science are bad because I don't understand the subject maybe is the way that our teacher teach us I don't know but in Science I don't perform well as other subjects. But more special in chemistry I don't understand anything.* ***Sometimes I just tell myself that Science is for boys because many things that we do in chemistry many boys pass it. But girls fail(ed)***"

The summary of the qualitative data captured above is given below in the form of a bar graph.

Diagram 4.3.1: *Learner interest in doing Science as categorized in groups in percentages*



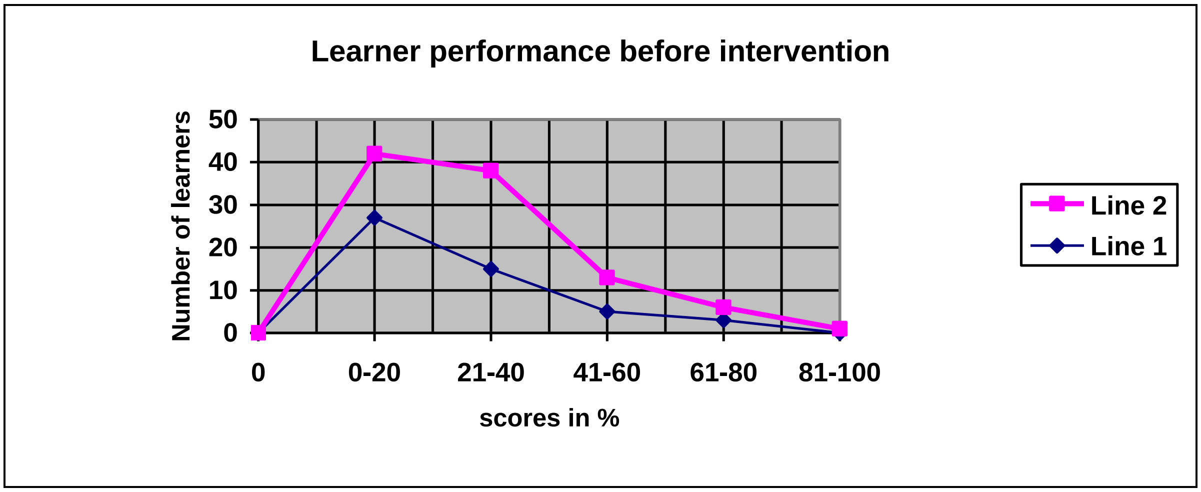
Apart from the strong overlap between the QLTG and the NIG as depicted above, the nature of the data can be summarized by grouping it into two main categories. The SBG and the SCG can be combined to form the motivated group whilst the rest (SOG, QLTG and NIG) combine to form the non-motivated group. In terms of this categorization, the motivated group forms 35% of the Grade 11-D class whilst the non-motivated group forms 65%.

4.4 Learner Performance in the test

Although the teaching methodology used during this study was context-based in nature, the test used at the end of the intervention to check on whether the use of context-based teaching methodology can lead to improved learner performance in Science was traditional in nature (see Appendix F). Quarterly tests were being administered at the school and it was felt that using a different style of testing might have jeopardized learners' chances of doing well as they were not used to writing tests that are context-based in nature.

The learner scores in this test were then compared to their scores in a test done before the intervention. The two graphs below drawn on the same set of axes (Diagrams 4.4.1) provide the learner scores on the two tests.

Diagram 4.4.1: *Frequency Distribution Graph on learner performance before intervention.*



There is some improvement in the scores obtained by learners in the test after the intervention. However, both the frequency graphs based on the scores obtained by learners in the two tests are positively skewed. A positive skew of test scores on a frequency graph indicates poor performance. However, over 20 learners scored between 21 and 40% in the test given after the intervention compared to only 15 in the same category before the intervention. Only five learners scored between 41 and 60 compared to eight in the same category after the intervention. At least one learner scored between 81 and 100 on the test after the intervention compared to none before the intervention. The average learner scores in the two tests are 26.5% and 35.7% respectively which shows an improvement in learner performance from the first test to the second. The bar graph below summarises the comparisons of learner performance in the tests before and after the intervention.

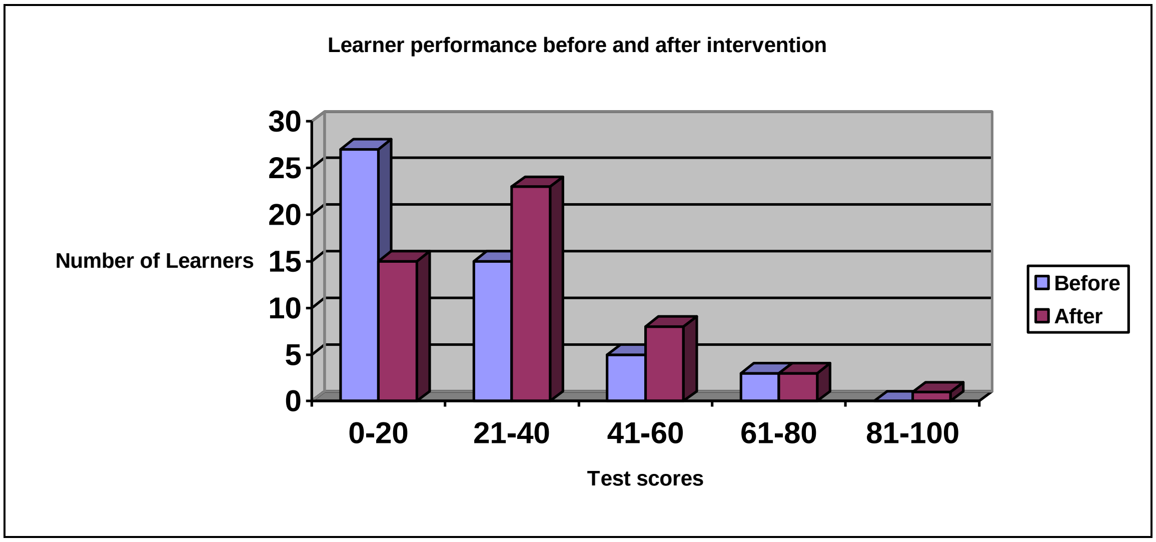


Diagram 4.4.3: *Learner performance in the tests before and after the intervention*

4.5 Classroom Observation

"It's the second day of the intervention and I am walking towards the Grade 11-D physical Science classroom. The bell went as I leave the staffroom and learners are going from one classroom to another as they change periods. I went and stood beside the door to our classroom. That day, the learners arrived in class less than five minutes after the bell. I could basically see them pushing through their peers standing in their way and rushing towards the classroom. This is something we never had in our first day where more than ten minutes were actually wasted as we waited for all the learners to arrive into the classroom." (From the researcher's journal)

I noticed during my visits and my stay at the school during the study that it was always a struggle to get learners into class after breaks. A number of reasons could be ascribed as to why the Grade 11-D learners suddenly saw the need to be in class on time. One of the reasons could be that they were beginning to enjoy what was happening in the classroom and therefore would not want to miss out by coming late; or that I was stricter in exercising discipline in class compared to their educator. Their coming early might have occurred because of their fear of getting punished.

Most of the time the learners were made to work in groups in the classroom. They were engaged in activities that needed discussion and were expected to provide feedback in the form of reporting or to use the ideas discussed in their respective groups to effectively engage in whole class discussions. Four of the different approaches to group work discussed in Chapter 2, as outlined by Brodie and Pournara (2005) i.e. the ***co-operative learning approaches, collaborative problem-solving approaches, situated approaches*** and ***socio-political approaches*** were used in the different classroom activities as found in the module.

The *co-operative learning approach* was used in Activity 1 to engage learners in answering questions 1 to 6 in the module. The level of cognitive engagement in this activity was very basic. Learners only had to discuss simple issues such as how a brazier is made, examining a piece of coal and saying what colour it is, etc (see appendix). It was, however, very interesting to see how learners tried to find scientific explanations as to why the brazier is made the way it is. One specific issue that emerged strongly during the discussion was why holes around the brazier are made in the area where the pieces of coal are placed. It emerged very clearly from the discussions that learners had a good understanding of the role of oxygen during combustion.

The *socio-political approach* was used for question 7 in activity 1. The question asked learners to list all the harmful effects they could think of that coal has on the environment and how these effects could be minimized. Each group was to answer this question on a flip chart provided and elect a group spokesperson to report on their discussion. Apart from ensuring equity in the classroom in terms of gender bias within the different groups, this approach was also used to avoid any prejudice that could emerge in terms of where the different learners were coming from. The question could have been interpreted by learners who were staying in the nearby informal settlement as one that assigned blame, i.e. responsibility for the deterioration of the immediate environment, including the school area, as most coal is used in their area. In dealing with the first part of the question, learners listed effects such as retardation on plant growth, respiratory problems leading to ill-health in people and even death at times, quick fading of paints on walls and the rusting of metal structures.

The second part of the question sparked a very interesting debate. As learners reported in turn on the discussions of their groups on ways of minimizing the effects of coal on the environment, it became very clear that there was more than one answer. The socio-political nature of the question threw up answers such as providing electricity for all to stop the burning of coal by people in the informal settlement. Six of the seven groups (86% of the class) supported the idea of 'electricity for all'. The debate started when one of the seven groups (14% of the class) argued that the idea of 'electricity for all' was not a solution as long as coal is still used to generate electricity. They pointed out that coal is burnt in very large quantities in our country to produce electricity. Therefore, the idea of electricity for all would actually increase the environmental problems that are facing the country, instead of providing a solution. Alternatively, the group mentioned the use of solar energy as the best solution as it has no environmental impact. According to this group, the government could, as a way of dealing with the problem, provide effective solar power panels to the community (even to the whole country) in order to end the environmental problems caused by the use of coal as a source of power or means of generating electricity.

The *collaborative problem solving approach* was used in Activity 2. This activity mainly engaged learners in writing chemical equations to explain the chemical processes that occur when coal is burnt. This activity not only offered an opportunity for learners to see how the harmful products resulting from the burning of coal are formed, but also provided a great opportunity for learners to learn about the use of chemical equations in symbolizing a chemical process. Other necessary scientific knowledge, such as balancing of chemical equations, was addressed during this activity. The learners worked together and shared ideas, e.g. what symbols should be used for the elements that coal is composed of, namely, carbon and sulphur; what chemical formulae would represent the products of these elements as they burn in oxygen. It was clear that learners benefited (learnt) from each other as they engaged in the activity. No single learner claimed to have answers to all the given tasks in the activity. We (the teacher and the researcher) were also available to assist wherever necessary.

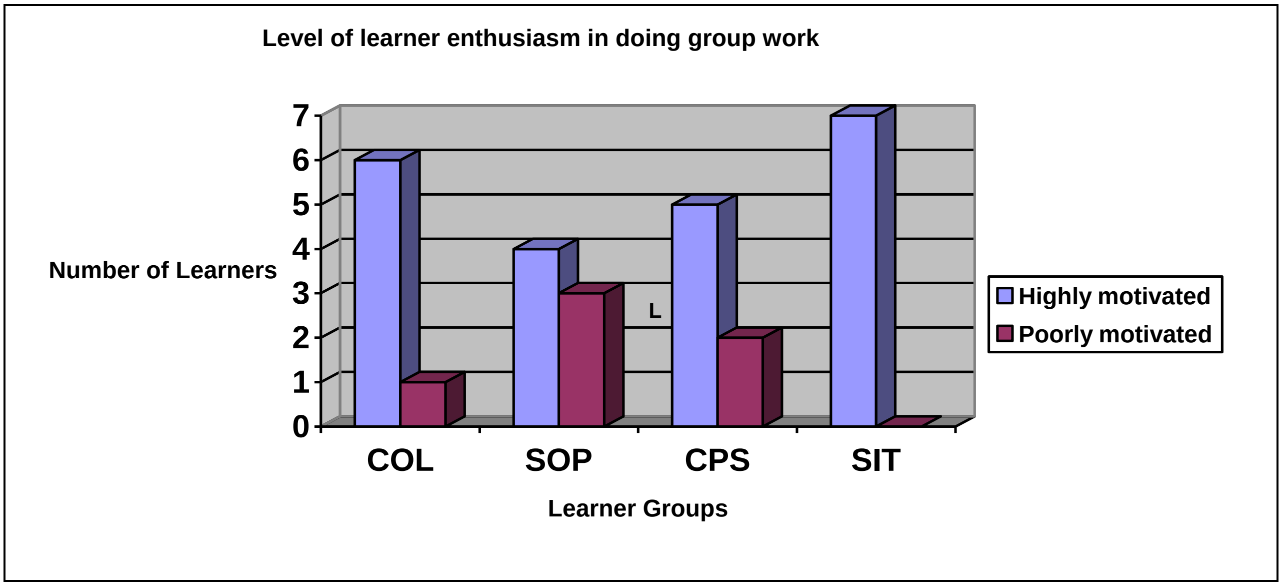
The *situated approach* to group work was used in Activity 5. Here learners had to prepare and use hydrogen sulphide gas by passing it through solutions of potassium permanganate, potassium dichromate and iron (III) nitrate. They then had to record any observations they made. They had to move from one chemical station to another and performed relevant activities in each. They were attired in white laboratory coats and used safety goggles. This equipment was insufficient and had to be shared, one group at a time. It was amazing to see how the learners' identity as science pupils emerged.

"You are looking at Dr. Masilo in her surgery. Can the next patient come in please"

said Lucia (not her real name), as she finished putting on her safety laboratory clothing. This activity enabled learners to see themselves as scientists at work. There was a high level of enthusiasm in the classroom as learners moved around and performed their experiments.

The level of enthusiasm in terms of learner participation in group work, based on the four group work approaches cited above, was captured and quantified in terms of the number of groups that showed high and low levels of enthusiasm. The categorization of the groups as either highly motivated or poorly motivated was purely based on observation of how the groups engaged in the given tasks. The more enthusiastic and less enthusiastic groups in the different tasks whilst were classified as highly motivated and poorly motivated respectively. Some groups were more enthusiastic in one particular group work approach and less enthusiastic in others. The enthusiasm with which learners engaged each other during discussions and presentations was used to gauge the level of motivation. The four groups were coded as follows, and a graph was drawn to show how the levels of enthusiasm differed. As can be seen, learners enjoyed working and participating in group work. Their interest in learning was to a large extent stimulated by the use of group work in the classroom.

Diagram 4.4.4: *Levels of learner motivation during group work*



4.6 Learner Interviews

Ten learners were randomly selected and asked to participate in an interview session at the end of the intervention. The random selection was done to ensure that not only learners who showed more interest in learning in class were chosen to participate in the interviews. The selected learners agreed to participate and were interviewed according to the schedule given in Appendix D. Learner responses to the interview after the intervention generally indicated that their lack of interest in doing Science stems from the manner in which it is taught. Some responses also indicated poor educator commitment and learner ill discipline in the classroom as some of the obstacles leading to poor performance in Science and lack of interest in doing it. It also seems that the learners used the interview as an opportunity to say how badly they were taught by their teacher (their teacher was not present during the interviews). This also made me wonder what the learners would say about me if somebody else interviewed them with regard to how I taught them during the intervention.

The first question asked learners to give reasons for choosing Science in Grade 10. Nine of the ten learners indicated the benefit associated with doing Science in terms of career and workplace opportunities as the main reason for choosing the subject. Only one learner indicated that she chose to do Science because she found it to be fun and enjoyable. This response is in line with the Science Content Group (SCG) discussed earlier in this chapter.

All interviewed learners indicated that they began to understand and enjoy learning Science during the implementation of the context-based module. As I was the interviewer, it is likely that the learners wanted to make positive statements about what I did with them. There was a possibility that that their statements were not honest. However, they indicated several reasons for their sudden change in perception towards learning Science.

Samuel: *"The whole lesson was kinda like fun, ja very fun I enjoyed it. The experiments, talking in groups I liked that. Although understanding those chemical equations was difficult"*

Mongezi: *"I have always been passionate about Science. I think I have just become more passionate. Sulphur compounds consist of many things that happen everyday that I did not know. It made it easy for me to follow the lesson. I wish we learn Science this way all the time. More especially when it comes to talking in groups and presenting our work"*

Although no question in the interview asked learners to comment on teacher commitment to the teaching and learning, the three learners quoted below felt that this was one of the reasons why their performance in Science was poor. Thus the rationale of the quality learning and teaching group (QLTG) discussed earlier in this chapter was also relevant.

Rulani: *"I don't want to lie. Learners in other schools pass Science. There is no free period in those schools. Meneer is sometimes here and not here and he is not punctual. … should also explain the notes he give us. Rude behaviour by learners is also a problem"*

Collen: *"…sometimes our teacher writes notes on the board without any explanation. He should give examples when writing on the board. The teacher must show some excitement when teaching Science. Our teacher does not show any interest when teaching and so we become not interested"*

Musa: *"I don't regret having chosen to do Science. I used to pass well in the other grades. I was 3rd in Grade 120. The problem started in Grade 11 with all the new topics. I began not to care about Science anymore because the teacher is not in class at all times to teach us and this cause problems"*

The following are some of the suggestions made by learners in their response to a question on what needs to be done to make the learning of Science fun in the classroom. Most, if not all, still speak to the need for quality learning and teaching in the classroom.

Tumi: *"We must do more practical work. Have trips to places where things are really happening… teacher who is present at school most of the days. Not only present but present in the classroom"*

Roxanne: *"I think the teacher should take it (Science) out of the textbook. He should not concentrate on the textbook but come up with his own creative ways"*. The learner here seems to be suggesting that reading from a textbook when teaching does not make Science fun to learn.

Rona: *"It's (Science) definitely fun when you have trips to Science places. Someday we went to …We saw all the things. There is a generator. You put your hands on it and your hair stand up. Its fun 'cos you learn what's happening"*

Through interviews it was established that about 70% of learners began to show signs of being motivated to do Science, compared to 35% in the initial stages of the administration of the questionnaire. Many factors may have influenced the kind of responses given by learners during the interview. The fact that I conducted the interviews may have influenced the learners to speak positively about what we did in class.

4.7 Educator Interview

The educator was interviewed making use of the schedule in Appendix E. He was very impressed and happy with how the module was designed and how it was implemented in the classroom. He found it very interactive; it also engaged the learners. He was also satisfied that most of the time it was learners who were working instead of the two of us doing the talking and teaching. He confessed that he did not believe learners could come up with the kind of reasoning that they used during discussions.

On the context-based approach to the teaching of the chemistry of sulphur, the teacher indicated that this was a useful starting point for the lesson. However, he indicated that any teacher who wishes to use the approach must be prepared to do a lot of preparatory work. He was also honest in indicating that this was something he was not used to doing. The lesson involved much practical work for learners and much educator work in preparing the demonstrations. This, according to the educator, poses a huge challenge to schools like his due to the lack of laboratory equipment. This was a genuine comment as most of the equipment and chemicals used during the intervention were supplied by the researcher.

It was clear, too, that the teacher needed to be well versed in subject content before teaching any topic in Science via the context-based approach. The approach, according to him, requires the teacher to be an expert in Science. He believes he has learnt a lot in terms of both the subject content, in this case the chemistry of sulphur, and teaching approaches. Thus the importance of pedagogical content knowledge in the teaching and learning of Science cannot be over-emphasized.

4.8 Chapter Summary

This chapter outlines the results of the study. It shows how the intervention (a context-based lesson) assisted learners in developing interest and hence a positive attitude towards the learning of Science. Many learners indicated that the approach used in the teaching of the chemistry of sulphur suddenly made Science fun and enjoyable to learn. Although the teacher hinted that the test I gave after the intervention was of a higher standard than what the learners were accustomed to, there was also a slight improvement in learner performance in a comparison of test scores before and after the intervention. However, the study was done on a very small scale and this makes it not possible to draw any general conclusions on the kind of answers found.

Furthermore, learner responses to interview questions also raise issues beyond the scope of the study. The responses by learners indicate that the level of motivation and commitment of the teacher in teaching Science is very low. Some learners claimed that they enjoyed science periods because very little teaching and learning occur and therefore they have enough time to socialize.

The teacher does acknowledge that there were aspects of the chemistry of sulphur that he did not have an understanding of and therefore it would have been difficult for him to teach the concept. I believe this is a sensitive area for teachers. It is usually very difficult for teachers to accept that they are not well versed in certain areas as this suggests that they are under qualified. However, he believes that the context-based approach is a very effective way of teaching that he thinks he can make use of. But he is quick to point out that much preparation is required. He indicates that this is something he is not used to. This could be the case with most Science teachers in the country, especially those from underperforming schools. It could be useful to train educators on how to develop modules of teaching content in order to cultivate a culture of thorough preparation.

CHAPTER 5

DISCUSSION, RECOMMENDATIONS AND CONCLUSION

5.1 Introduction

This study focused on the effect of context-based teaching methodology in the teaching and learning of Science in the classroom. As discussed in Chapter 2, context-based teaching methodology is informed by the constructivist paradigm on learning which believes that knowledge is constructed by the learner. Context-based teaching methodology supports the use of contextual issues as starting points in the teaching and learning of Science. Apart from making the learning of Science relevant to students, the use of contexts as starting points in the teaching assists the teacher in "recognizing the importance of prior or existing knowledge as a factor in entrenching new knowledge" (Tema, 2002, p. 128). Holbrook (2005) agrees that this teaching methodology enhances the relevance of scientific concepts as it encourages student involvement and allows for construction of new knowledge from prior constructs. The context-based teaching methodology therefore refutes the traditional methods of teaching Science at schools which "employ a lecture format of instruction in which the majority of students are passively listening to the instructor and jotting down notes" (Dufersne et. al, 1996, p. 3).

5.2 Answers to Research Questions

The main focus of this study was to establish the effects of a context-based teaching approach to both learning and performance in Science. In providing answers to this question, the study focused on answering three research questions. The first question was:

Does a context-based teaching approach stimulate learner interest in doing Science and foster the development of positive attitudes towards the learning of Science?

According to the findings, the group of learners who participated in the study had little interest in learning Science before the intervention. The responses to the questionnaire that dealt with interests and attitudes showed that the learners were not enjoying learning Science and that they did not look forward to attending lessons. Over 10% of the learners indicated that they chose to do Science not because it is fun, but because of the good employment opportunities after Grade 12 or the availability of study bursaries for those who pass Grade 12 Science.

Responses to questions asking learners why they found Science unfulfilling at school mainly pointed to the manner in which it is taught. When asked to suggest ways in which the learning of Science could be made fun in the classroom, learners responded by saying that there is a need to (1) do more practical work in the classroom and (2) be given opportunities to participate in science expos and competitions. Furthermore, the learners felt that the teacher was not fully committed to teaching them as he would absent himself often from school and when he was present, he would sometimes sit with them in class without any teaching taking place. I believe that this is one of the reasons why learners, before the intervention, would drag their feet when coming to class. .

However, the situation seems to have changed as seen in classroom observation and the responses to the interview questions by learners at the end of the intervention. Contextualisation of the lesson on sulphur and sulphur compounds with the burning of coal as a starting point fascinated the learners. The burning of coal was something they could identify with and relate to. This seemed to capture their interest in learning about the topic. Thus the topic, based on a familiar social issue, was seemingly attractive for learners and stimulated their interest. They knew the problems associated with the burning of coal and therefore could discuss them openly and fully during group work. This made their learning more meaningful. It became much easier for learners to grasp the scientific (chemical) concepts based on the chemistry of sulphur and sulphur compounds after discussions on the impact that burning coal had on the environment and health of people. However, this did not translate into a marked improvement in learner performance. Young (2005) suggests that meaningful Science learning programes should be composed of sequences of lessons, with a common beginning, on a socio-scientific context. He further emphasizes that the teaching should progress from the familiar (the societal issue) to the unknown (scientific concepts) (Young, 2005). The module used in the intervention supports this notion as it used the socio-scientific issue of the burning of coal to introduce and teach a science lesson on sulphur and sulphur compounds.

The intervention lesson methodology also engaged the learners. The module on which the lesson was based seemed to capture the interest of learners as well. Learners worked together in groups discussing science issues. They would present their ideas and give scientifically based reasoning in advancing their arguments and doing presentations. Some of the questions posed were in problem form and they were expected to provide solutions to such problems. The group work approach seems to have motivated learners to participate fully in the lessons as well. During the group work sessions, learners would put together ideas on how to work out solutions to certain given questions/problems on the worksheets and, if they exhausted their ideas without finding a solution, they would always be free to request help from the teachers.

Experiments also played a role in capturing learner interest in doing Science. It was very interesting to observe learners identifying themselves as scientists, doctors, engineers, etc when they put on their white coats, safety goggles and gloves before the experiments. They even volunteered to stay in class, completing their experimental tasks during breaks, and were even prepared to stay behind after school if their tasks had not been completed.

The second research question was:

To what extent does a context-based teaching approach affect learner performance?

Firstly, apart from comparing learner scores in the two tests done before and after the intervention, observations made during lessons from the beginning to the end of the intervention show that learner performance improved with regard to other skills, such as communication, time management (especially during group work), and the use of mind maps during the brainstorming of ideas and presentation skills. Thus, based on the researcher's observation, learners improved on the said skills over the period of the intervention. The level of learner confidence also showed an improvement when learners made presentations. .

Secondly, a comparison of learner scores of the two class tests written under controlled conditions was done. One test was written before whilst the other was written after the intervention. According to the scores, learners performed better in the test given after the intervention. The class average on the test given before was 26.5% whilst the average for the test after the intervention was 35.7%. One learner was able to score over 80% in the test given after the intervention compared to a highest score of 73% in the previous test. However, Bennett et al. (2005) argue that, although a context-based approach to the teaching of Science has been found to improve learner interest in doing Science and does foster the development of positive attitudes, these do not automatically lead to improvement in learner-performance. This seems to be the case here as learner performance remained disappointingly low.

The third and last question was:

What challenges face educators who attempt to use a context-based approach to the teaching of Science?

The information gathered during both my informal discussions and the interview with the teacher revealed a number of interesting issues around the challenges that he thinks he would face if he were to use a context-based approach to the teaching of Science. Firstly, the teacher felt that he needed to be competent in science content. The teaching style when a context-based approach to the teaching of Science is used is such that learners are afforded an opportunity to voice their science ideas, which may not necessarily be correct scientifically. This was evident during the intervention when learners discussed science issues in groups. Most of the learners believed that only fumes from open coal fires were harmful to human health and not when coal is used to generate electricity. They believed that if the government could build houses for the people staying in informal settlements and supply them with electricity, the problem of pumping poisonous gases from the burning of coal would be solved. Learners did not know that the burning of coal at electricity generating plants releases larger quantities of sulphur dioxide and carbon dioxide into the atmosphere compared to the quantity produced when coal fires are lit in informal settlements. The teacher should then be able to guide and assist learners to construct new knowledge by playing the role of a 'coach'. Learners are helped to see why some of their initial conceptions are incorrect and therefore need to be either discarded or refined. This is in line with the notion of teaching for conceptual change as envisaged by constructivist learning theorists (Carr, 1994, Hewson et. al. 1998, Scott, 1994).

Secondly, the teacher felt that a context-based approach to the teaching of Science demands thorough preparation. Apart from ensuring that the selected socio-scientific issue is conceptually rich enough to bring about relevance of the scientific concepts that the teacher is intending to teach, the teacher is also faced with the curriculum duty of packaging such content in a coherent sequence of lessons in the form of a module. A teacher is therefore viewed as a learning material developer within the constructivist view of learning. Planning at this level takes such a long time that the teacher has to be dedicated, devoted and passionate about the subject. Even in this short intervention, I produced 35 pages that comprised an original module – this took two to three weeks to develop.

Thirdly, the teacher also felt that using a context-based approach to teaching in Science demands that teachers assume the role of curriculum planners. This feeling was very true in my case. Apart from packaging the content into coherent sequential lessons forming a module, I had to plan the progression of the teaching and learning as well as how long it would take to complete a particular module. This included planning classroom practices such as whole class discussions, group work, learner presentations, practical experiments and practical investigations. Since the burning of coal was central to the teaching of sulphur and sulphur compounds in my case, the first lesson was introduced by bringing a brazier into the classroom. The period was used to discuss why suddenly everybody became uncomfortable as more and more gas molecules began to permeate the classroom. This was done to ensure that learners engage effectively in their own learning. In the traditional approach to teaching, the 50-minute period would have been more than enough to introduce and teach almost half of the concepts based on sulphur and sulphur compounds. Dufresne et al. (1996) state that when a context-based method of teaching is used, "the time we devote to lecturing is decreased, while the time students devote to developing and refining conceptual understanding is increased. The instructor's role, therefore, more closely resembles that of a coach than a dispenser of information" (Dufresne et. al, 1996, p. 4).

5.3 Incidental findings aside from research questions

The study made a number of incidental findings. Firstly, it was discovered that very little, if any, practical work had been done with the learners. The teacher did not know where to locate the apparatus and chemicals I needed (the laboratory). The apparatus and chemical bottles that were eventually found were dusty, showing that they had not been used for a very long time. One of the excuses offered by the teacher for not doing practical work with his learners was the huge learner numbers in the classes that he was teaching. Each of his four classes comprised 50 learners. However, the intervention helped the teacher with ideas on how to handle practical work with huge classes. During the intervention, learners were divided into groups of ±10 for practical work and ±5 work stations would be set up. Learners would then perform the practical work in all the stations by moving from one station to the next until all the experiments had been done. The teacher was happy with this solution but he was quick to mention that much preparation has to be done before practical work may be commenced. The intervention exposed learners to practical work which became one of the areas they were interested in. Learners were also not given opportunities to learn through field trips. Although a field trip to an electricity generating plant would have been ideal, it was not possible to take learners to such areas due to a lack of resources and time constraints.

Secondly, responses to some of the questions on the questionnaire indicated that some girls believed that boys have the ability do well in Science. The perception was that boys obtained good marks in Science compared to girls, nor does it matter how hard girls work because boys would always perform better in tests and examinations. They attribute this to the 'fact' that certain things in Science are better understood by boys. However, learner performance in the tests written before and after the intervention indicate that girls actually perform better than boys. The myth that boys do better in Science than girls was therefore discussed with the class.

Thirdly, it was also noticed during the intervention period that the learners showed great interest in the use of group work. Although the levels of interests differed from one group work approach to another (refer to Chapter 4), the general feeling was that learners enjoyed being engaged in discussing science issues and doing practical experiments in groups. There was also a sense of ownership of ideas when group representatives made presentations on tasks that needed feedback, such as the discussion on how we could reduce the carbon dioxide emissions in the atmosphere in order to avoid negative environmental impacts. During the intervention, learners also showed a sense of respect for time as they ensured that they were in class on time both after break and during change of periods. It is, however, not very clear whether they did this because they enjoyed what they were doing in the science classroom or wished to avoid getting into trouble with the 'new teacher' (researcher) who might enforce discipline.

Finally, in a comparison of tests on the same topic, learners performed better in the test given after the intervention. But the difference in performance in the two tests was very small. There could have been a number of reasons why the difference in performance was small: (1) learners showed a lack of knowledge of basic concepts in chemistry during the intervention; (2) the test was based on traditional teaching methodology when the teaching and learning was done using an STS-based teaching methodology.

5.4 Implications and Recommendations

The findings made in this study have direct implications for the teaching and learning of Science in the classroom. As a result, the following recommendations are made with the hope that they can assist teachers in ensuring that the learning of Science is made more meaningful. As mentioned in the previous paragraph, one of the implications of the findings in this study is that Science teachers should be trained to become learning material developers. This is also put forward as a prerequisite for educators in the National Curriculum Statement. There is also a need for educators to be competent in the subject content of the sciences. It therefore becomes necessary for subject advisors and curriculum designers to plan and package effective in-service training workshops/courses to 'sharpen' educators with regard to content competencies. Furthermore, the findings in this study highlight the need for thorough planning by educators for delivery of the curriculum if the teaching and learning of Science is to be made meaningful.

The findings in this study tempted me to speculate on the minimum level of commitment that can be expected from teachers to ensure that learning takes place in the science classroom. This resulted in the development of the model below. Although the model is based only on expected teacher levels of commitment in teaching (Science) which are likely to bring about meaningful teaching and learning, it does not underplay the importance of other factors such as the differing states of school infrastructure, ranging from those with magnificent buildings to those with broken down buildings, lack of doors and windows, electricity and sanitation and few books or no resources at all (see Rogan and Grayson, 2003). The model is also useful as it shows how the quality of teaching could be categorized in order to inform teacher developmental strategies.

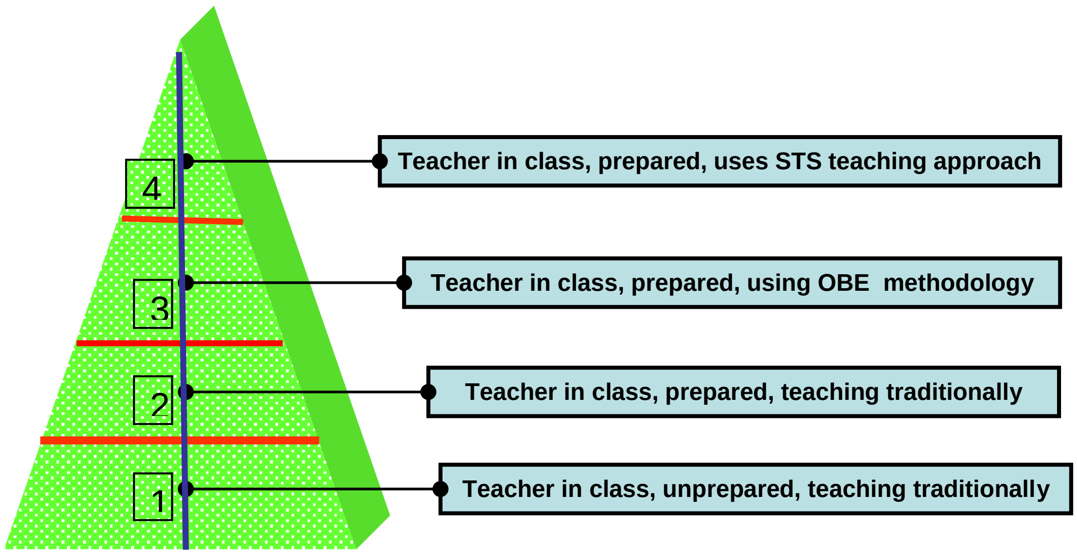


Figure 5.1 *Levels of teacher practice in the classroom as adapted from Rogan and Grayson (2003).*

A teacher at level 1, *Teacher in class, unprepared, teaching traditionally*, is one who comes to class with no preparation but is able to make use of what is readily available. Level 1 also shows the minimum learner expectations of the teacher. One of the learners' concerns about the teacher in this study was that he was more than often absent from school and that he would sometimes be present in class without teaching. The teacher at this level depends on readily prepared learning materials such as textbooks and other learning materials provided by head of departments, subject heads and/or subject facilitators. A basic traditional mode of teaching, where the teacher writes notes on the board for learners to copy, is dominant. The teacher at this level is unable or not prepared to develop his/her own learning materials. This is what I would call teaching at a basic level. Teachers at this level are not very clear on science concepts but make use of readily prepared materials to explain the concepts to the learners. Mr Mawawa, the science teacher at the school where this study was done, was operating below this level. However, the intervention was successful in assisting him to improve his teaching strategies such that he was able to operate at level 3 at the end.

The second level, *Teacher in class, teaching traditionally*, applies to those teachers who are motivated to some extent. They are prepared to teach and commit themselves to ensuring attainment of good results by learners. However, they are not ready to develop learning materials nor even attempt to make Science relevant by bringing context into their teaching. These are educators who use traditional teaching approaches and are successful in producing good learner results at the end of Grade 12 year on year. Educators belonging to this level teach for the examination. Their teaching throughout the year puts more emphasis on showing learners how exam questions at the end of the year will be structured. Learners are mostly kept busy practising how to answer a series of exam-related questions. The success of learners is measured in terms of how correctly they answer most of the given questions and not on how much understanding they display. Learners at the school where the study was conducted would have been happy to have a teacher operating at this level. The good marks they would obtain in science tests and examinations would serve as a motivation for them to study hard.

The third level, *Teacher in class, prepared, using OBE methodology,* applies to teachers who are able to develop learning materials that are satisfactory to some extent. These educators are also able to bring context into their teaching of Science. However, contextualization of Science in their classes is only done to a limited extent. Learners are made to work in groups but there is no effort to make the teaching and learning of Science learner-centred as discussed in Chapter 2. Although my intervention was planned to be contextual in approach and was based on STS principles, it had to be adapted due to the curriculum needs of the school (such as controlled tests for learner portfolio marks) and ended up being pitched more or less at this level.

The fourth level is termed *Teacher in class, prepared, uses STS teaching approach*. This is the highest level at which teachers can operate, according to this model. The divide between teachers belonging to the first three levels and those at level four is that level four educators are curriculum planners. They are able to plan their teaching effectively by packaging the science content as given in the syllabus into discrete but coherent learning programmes. Consultation with learners is also made in order to ensure that all relevant projects in which learners engage during the year are accommodated in the learning programmes. This level is similar to that of Rogan and Grayson (2003), which claims that a level four teacher "…facilitates learners as they design and undertake long-term investigations and projects. (And) Assists learners to weigh up the merits of different theories that attempt to explain the same phenomena" (p. 1185).

The science syllabus is contextualized to ensure meaningful learning. Very few of our teachers operate at this level.

Lastly, it is worth mentioning that, although the four levels of teacher classroom practice do not form part of the research questions, they help to show progression from traditional to context-based teaching methodology. The use of similar terms when labels are assigned serves to indicate the overlap that exists between the levels. In a similar model where concentric circles are used, Rogan and Grayson (2003) explain that "higher levels incorporate the practices of the lower ones, rather than replacing them" (p. 1186). The triangle in this model was deliberately used to show clearly the progression from one level to the next and the level of demand that such a progression exerts on the teacher as s/he moves from one level to the next. Mr Mawawa (not his real name) indicated that the use of a context-based approach to teaching is more demanding as it involves rigorous preparation. It was therefore a difficult adjustment for him to improve his teaching practices to level three (he operated below the basic level according to the model).

5.5 Areas for further Research

New research questions could arise from this study. In terms of classroom practice, a question that readily presents itself is:

What factors lead to poor teaching of Science by educators?

The issue of girls feeling that boys have a natural ability to understand Science better than they do is also an area of interest. The research question here could be phrased this way:

Do boys have a natural ability to perform better than girls in Science?

5.6 Limitations of the study

A number of limitations were experienced by the researcher in as far as the curriculum is concerned. Firstly, the demand involved when one is to implement a STS-based teaching methodology is such that it would require a whole year or even a three year FET curriculum planning (Aikenhead, 1994, Rogan and Grayson, 2003). This was not possible as the researcher is not a school-based educator. Secondly, the need to consult learners on what science projects need to be done throughout the year is important (suggested by Rogan and Grayson, 2003). Science projects would not have materialized at the school where the study was done due to the poor culture of teaching and learning. The culture of learning has first to be created by making learners accustomed to daily school work and the writing of science project reports. This would enable them to participate fully in learning and to even take charge of their own learning. Although the module and the teaching methodology thereof used in the study were to a large extent context-based, a full implementation of an STS based teaching was not possible given the constraints stated above. The test administered at the end of the intervention had to take the format of a traditional test since it had to be written as a controlled test by all the Grade 11 science groups and not only Grade 11-D, which was the group involved in the study.

The study was conducted at a high school in Soweto, in one of the fifteen Districts of the Gauteng Department of Education (GDE). It was a small scale study that involved only one class. Its results can, therefore, not be generalized beyond the school itself. The researcher also has no intention of claiming that the findings of this study could be used to explain and describe the state of teaching and learning in Science elsewhere than in the school where it was conducted. Therefore, the recommendations made in this study are not transportable to other settings.

5.7 Conclusion

This study focused on establishing the effects of a context-based teaching methodology, which is learner-centred, on learning. In spite of the limitations discussed above, it was established by the study that learners relate better to what is taught when a scientific, societal issue is used as a starting point for the teaching and learning of Science. The study also revealed that learners become more interested in learning when the teaching content is contextualized to their everyday life. Furthermore, it was established that when a context-based teaching methodology is used in the teaching and learning of Science (even though it was implemented in a limited way), positive attitudes towards Science are fostered. The study also established that performance may improve when a context-based teaching methodology is used. However, it is worth mentioning that only a slight improvement in learner performance was recorded.

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