

https://dspace.org/

Investigating Lesotho junior secondary science teachers' perceptions and use of laboratory work.

Monare, Thulo Julius

2010-11-09
http://hdl.handle.net/10539/8859

Downloaded from a DSpace repository. https://dspace.org/

Chapter 1

Introduction to the study

1. Introduction

Laboratory work has long been recognized as an effective instructional strategy in science teaching and learning (Kipnis & Hofstein, 2007). Hofstein and Lunetta (2004:31) define laboratory activities as "learning experiences in which students interact with materials and/or with models to observe and understand the natural world". These activities may either be done inside or outside the classroom. Hofstein and Lunetta (2004) regard the laboratory as an appropriate learning environment for promoting meaningful learning, enhancing students' understanding of both scientific knowledge and the nature of science. The use of the laboratory to promote learners' engagement in scientific inquiry is supported by Hodson (1996). Scientific inquiry is the process of development and validation of scientific knowledge. It constitutes the various ways of studying the natural world, proposing ideas and collecting evidence to justify assertions and explanations (Hofstein and Lunetta, 2004; Songer, Lee and McDonald, 2003; Windschitl, 2003). The process of inquiry involves using tools, proposing problems for investigation, formulating hypotheses, designing procedures, collecting data, analysing data, processing answers and explanations, prediction and communicating results as well as identifying assumptions and use of logical and critical thinking (Songer et al., 2003). School science laboratory inquiry is viewed as similar to the inquiry done by professional scientists as learners also investigate the world, propose ideas and justify explanations based on collected evidence. According to Hodson (1996) laboratory activities can only be effective if they are designed in such ways that students are afforded opportunities to engage in scientific inquiry. He argues that in any inquiry-based laboratory activity students attain conceptual understanding, procedural knowledge, and investigative expertise.

Although laboratory work is considered to be central in science teaching, there have been some criticisms against its use (Hodson, 1996). The laboratory has been described as being too teacher-directed in that students are denied the opportunity to design and conduct scientific investigations so as to develop critical thinking and problem solving skills (Hodson, 1996;

Hofstein & Lunetta, 2004; Tsai, 2003). It has been argued that most laboratory work follows cookbook-type and verificationistic approaches to experimentation, denying students the opportunity to engage in full scientific inquiry. Hodson (1990) has castigated laboratory work as being both confusing and unproductive largely because the educators themselves are not clear about why, when and how laboratory work should be used. He also points out that laboratory work is both over-used (used to achieve all learning goals) and under-used (its real potential not fully exploited). According to Hodson (1990) students should be the main focus when educators design laboratory activities to enhance optimum learning.

There is growing evidence that teachers might not be using laboratory work as effectively as they should (Kipnis & Hofstein, 2007). By effective here, it is meant ensuring that every laboratory activity achieves the purpose for which it is designed. Effective use of laboratory work for science teaching might be dependent upon teachers' own perceptions of the aims of laboratory work. In other words, the way teachers use laboratory work in teaching could be influenced by their attitudes, beliefs or perceptions of the purpose of laboratory work. While some studies (see, for example, Kang & Wallace, 2004; Millar, 2004) have explored the interaction between teachers' perceptions of laboratory and their use of laboratory strategies and activities, the nature of this interaction is still far from being understood (Vhurumuku, 2004). For example, how exactly do teachers' ideas about the purpose of laboratory work interact with the teachers' use of instructional strategies and learning activities? Moreover, none such studies have been conducted in Lesotho. This study investigated the interaction between Lesotho junior secondary school science teachers' perceptions towards laboratory work and their use of laboratory work strategies and learning activities in teaching. It aimed to bring some light onto our understanding of the nature of interactions among teacher perceptions of laboratory work and their instructional practices.

1.1 The Purpose of the Study

This study investigated Lesotho junior secondary science teachers' perceptions of the aims of laboratory work and their use of laboratory work teaching strategies and activities. Of interest was the nature of interaction between teachers' perceptions and use of laboratory activities. In

this study, *perceptions* mean the teachers' understanding, beliefs, orientations and values regarding the purpose and role of laboratory work in school science. Teachers' *use* of laboratory work refers to their choice, design and implementation of laboratory work activities (e.g. use of discovery, guided discovery, problem solving, and investigative, laboratory work activities) (Hodson, 1996).The study was guided by the following questions:

1. What are the teachers' perceptions of the aims of laboratory work in school science?
2. How do the teachers use laboratory work in the teaching of science?
3. What is the relationship, if any, between teachers' perceptions of the aims of laboratory work and their use of laboratory work?

In this study the term "aim of laboratory work" is taken to mean the same as "objective of laboratory work". By which it is meant the knowledge, skill, ability, understanding or attitude the learner is expected to attain as a result of or from doing laboratory work (Vhurumuku, 2001).

1.2 Rationale for the study

This research was motivated by the introduction of the new junior secondary science curriculum in Lesotho in 1998 (pilot stage) which gained full implementation in 2001 (see, Phakisi, 2008). This curriculum requires that in their teaching, teachers should use student-centered instructional approaches including practical experiments, inquiry oriented investigations, and projects involving analysis, synthesis and design (Ministry of Education and Training, 2006).

As already mentioned, laboratory activities are essential for the teaching and learning of science. Hofstein and Lunetta (2004) argue that if used properly, laboratory work promotes inquiry learning by engaging students in authentic and investigative activities. However, the use of laboratory activities to teach science might as well depend on teachers' own understandings and beliefs about the aims of laboratory work in school science. The assumption is that, what a teacher believes to be the major aim of laboratory work might in itself be a determinant of the instructional approach used by the teacher (Gwimbi & Monk, 2003; Hashweh, 1996; Kang & Wallace, 2005). Although studies examining teacher attitudes to laboratory work and their

practices during instruction have been done elsewhere, in Lesotho, nothing is known and understood about what teachers believe about the aims of laboratory work and how they use laboratory work in teaching science. A study of this nature was envisaged to be of value to curriculum planning for teacher education in Lesotho as well as useful for supporting teachers' effective use of laboratory activities at the secondary school level. Furthermore, the study was seen as important for providing feedback to curriculum developers about the enactment of scientific inquiry in the laboratory. There was an underlying belief that the study would lay a foundation for further research into use of inquiry-type laboratories in Lesotho and elsewhere.

1.3 The Lesotho context

In Lesotho, secondary education is completed over a period of five years; three years for junior secondary and two years for senior secondary. The purpose of Lesotho Science curriculum is to enable students to acquire knowledge, skills and attitudes in science and technology so that they become scientifically literate and functional citizens who demonstrate effective participation in innovative activities, decision-making strategies and solving social problems of scientific nature (Ministry of Education and Training, 2006). At junior secondary school level, the study of science is compulsory. All students are required to study science (Integrated Science) as a core subject. The subject comprises of three components, which are; biology, chemistry and physics. Teaching and learning involves both theory and laboratory work. Over the past decade, the Government of Lesotho has strived to ensure that many schools have reasonably well resourced science laboratories. This effort was aimed to enhance teaching and learning effectiveness. Some schools, however, still suffer from inadequate laboratory work materials and resources. As is the case in most African countries, under resourced laboratories are still common features in Lesotho.

At junior secondary school level, Integrated Science is allocated six forty minute lessons/periods per week. During their teaching, individual teachers decide how to allocate time between theory and laboratory work activities. At the end of the junior secondary school level, students write two external examination papers in Integrated Science. Paper I is multiple-choice and Paper II is divided into two sections consisting of semi-structured and essay type questions. All questions in each section are compulsory. In Paper II, answering some questions requires that students should

have done some laboratory work activities. The syllabus clearly stipulates that teachers should use student-centered instructional approaches (Ministry of Education and Training, 2006). The following activities/strategies are recommended; practical work through experiments, inquiry through investigations, and projects involving analysis, synthesis and designing of articles or items. Teachers are encouraged to use students' prior knowledge in their teaching and relate concepts in the curriculum to practical life experiences. As a result of shortages of laboratory equipment and materials, and because of large class sizes (about forty five in each class on average), most of laboratory work is done in groups. Teachers also normally demonstrate experiments to the large classes.

1.4 Theoretical Framework

This study is informed by theoretical constructs of scientific inquiry, inquiry-based instruction and constructivism. Inquiry-based instruction is linked to constructivism. The study is also informed by the current ideas in science education about what the most important aims of laboratory work are. In this section the theoretical constructs guiding the study are briefly examined. A detailed treatment of these constructs is given in Chapter 2.

1.4.1 Scientific inquiry and constructivism

The American *National Science Education Standards* (NSES) (National Research Council, 1996, p. 23) defines scientific inquiry as:

> "… the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world."

Scientific inquiry is composed of skills and abilities that are necessary to engage in scientific inquiry (doing inquiry) and understanding of the nature of inquiry. Abilities to do scientific inquiry include identifying scientific problems, designing and conducting investigations to solve the problems, collecting and analyzing data, interpretation of results and communicating the findings (Keys & Bryan, 2001; Hofstein & Lunetta, 2004; Abd-El-Khalick, Boujaoude, Duschl,

Lederman, Mamlock-Naaman, Hofstein, Niaz, Treagust, & Tuan, 2004; Kang & Wallace, 2005; Cuevas, Lee, Hart & Deaktor, 2005). Understanding the nature of scientific inquiry includes beliefs about the nature of science (NOS) and how scientists conduct their work to develop scientific knowledge. According to Abd-El-Khalick et al. (2004), inquiry, constructivism and the NOS are interrelated. They contend that inquiry and constructivism both emphasize student knowledge construction and the relationship between knowledge acquisition and conceptual development.

Inquiry-oriented instruction has been characterized in a variety of ways (Haury, 1993). According to Haury some science educators see it as actively involving students in hands-on, activity-based learning experiences while others associate it with the discovery approach in which students are engaged in investigative activities to understand the natural world. When viewed from a pedagogical perspective, inquiry-oriented instruction has often been contrasted with the traditional expository instructional methods.

Laboratory instructional practices have been associated with the methods, approaches, styles or techniques employed by teachers to enhance science learning. These practices include exposition, discovery, guided discovery, problem-solving, investigative, inquiry and constructivist approaches. The effectiveness of these teaching strategies has been based on their openness to inquiry or student-centeredness (Haury, 1993; Ravitz, Becker & Wong, 2000). Domin (1999) argues that from a constructivist view, the nature of the laboratory learning environment, which entails external influences interacting with the student during learning, should be altered in such a way that it produces desirable learning outcomes. Domin (1999) says there are four styles of laboratory instruction; structured inquiry (expository instruction), open inquiry, guided inquiry and problem-based inquiry. He argues that the distinguishing features of these styles are outcomes, approach and procedure. In structured inquiry, guided inquiry and problem-solving laboratory activities, the outcomes are predetermined, while in open inquiry activities the outcomes are undetermined. Structured inquiry and problem-solving activities use a deductive approach in which a general principle is applied to understand a specific phenomenon, whereas the open inquiry and discovery activities use an inductive approach in which a number of observations are made to derive a general principle. The procedure that is followed in

structured inquiry and discovery activities is provided in the laboratory manual or worksheet while in open inquiry and problem-based activities students design their own procedures.

According to Domin (2007) laboratory instruction is presented as a dichotomy of styles; the non-inquiry (expository) style of instruction and the inquiry-oriented (non-expository) style of instruction. In non-inquiry instruction, also referred to as the traditional, 'cookbook' or verification style, students verify known scientific principles by following a prescribed procedure to arrive at a predetermined outcome. Students read a detailed procedure from the laboratory manual or follow step by step instructions from the teacher. Expository instruction follows a deductive approach, and is criticized for putting little emphasis on the development of cognitive skills and for its ineffectiveness to induce conceptual change.

Supovitz, Mayer, and Kahle (2000: 332) define inquiry-oriented instruction as "a student-centered pedagogy that uses purposeful extended investigations set in the context of real-life problems as both a means for increasing students' capacities and as a feedback loop for increasing teachers' insights into students' thought processes". This style of instruction is basically a composite of three styles; guided inquiry (discovery), open inquiry, and problem solving (Domin, 1999, 2007). In guided inquiry the teacher gives a problem for which the students do not know the answer, but follow a given procedure to find the solution with guidance from the teacher. In open inquiry, teachers provide students with a problem to investigate but students decide on their own procedure to solve the problem. In problem solving, students generate their own problem and design their own investigation. This issue will be further explored in Chapter 2.

1.4.2 The aims of laboratory work in school science

The aims of laboratory work have been categorized for convenience by different researchers. Woolnough and Allsop (1985) have classified the aims of laboratory work into three broad categories: to develop practical scientific skills and techniques-which includes observation, measurement, estimation, and manipulative skills; to develop students' problem solving skills such as identification of problems, designing investigations, execution of the investigations and evaluation of the findings; and to help students get a feel of phenomena by directly interacting

with the physical world through their senses or instruments. Woolnough and Allsop argue that this interaction lays a foundation for a theoretical understanding of underlying scientific concepts. To Hodson (1993) the aims of laboratory work fall under five broad categories: to motivate students by stimulating interest and enjoyment, to help students develop laboratory skills, to enhance the learning of scientific knowledge, to develop students' expertise in using the scientific method, and to develop scientific attitudes such as open-mindedness, objectivity and willingness to suspend judgment.

According to Millar (2004), the aims of laboratory work can be grouped into four major categories, which are, the development of: conceptual understanding; learner interest and motivation; science process skills including laboratory skills; and understanding of the nature of science and scientific inquiry. The categorization of laboratory work objectives into four major groups as done by Millar (2004) was adopted for the current study. Millar's categorization was adopted firstly because the aims of laboratory work are stated explicitly and it was envisaged that these aims could be easily understood by the teachers participating in this study. Secondly, one of the aims emphasizes developing students' understanding of the ideas about the nature of science and scientific inquiry, which is highly advocated by the science education reform movement.

1.5 Literature Review

According to Hofstein and Lunetta (1982, 2004) many studies have shown that teachers often do not perceive laboratory activities as the principal means by which students' construction of scientific knowledge can be enhanced; hence they do not engage learners in inquiry-based laboratory activities that will develop their investigative and problem-solving skills. However, several studies (for example, Vhurumuku, 2004; Kang & Wallace, 2005) suggest links between teachers' attitudes and their instructional practices. Research has also shown that teachers might have different perceptions or attitudes towards the importance of laboratory work (see for example Lynch & Ndyetabura, 1983; Wellington, 1998). Teachers have also been known to use laboratory work according to their beliefs about teaching, learning, the nature of science and teaching efficacy (Gwimbi & Monk, 2003; Hashweh, 1996; Kang & Wallace, 2005). Several studies have revealed that in their teaching, most teachers use cook-book recipe laboratory

activities which merely verify the known (for example, Tsai, 1999; Roth, 1994). Teacher use of cook-book activities have been attributed to a variety of factors, including the nature of the curriculum and examination demands (Tobin & McRobbie, 1996). According to Swain, Monk and Johnson (1999), teachers' attitude towards undermining inquiry instruction can be explained in terms of their attitudes towards laboratory work. Both teacher attitudes and their instructional practices are expressions of what Shulman (1986) describes as pedagogical content knowledge. They might as well determine teacher survival in different laboratory teaching environments.

Hashweh (1996) characterized science teachers into constructivists and empiricists based on their epistemological beliefs. He described constructivists as teachers who believed that scientific knowledge is tentative, that students construct their own knowledge, and therefore recognized students' prior knowledge. Empiricists on the other hand were those teachers who believed that science is a body of knowledge which is accumulated through the "scientific method" used both as a paradigm for scientists and for instruction. Hashweh found that teachers' epistemological beliefs greatly affected the teaching of science due to the different instructional approaches used such as the use of a variety of instructional strategies and recognition of students' preconceptions by constructivists as opposed to their empiricists, counterparts.

It is argued that teacher beliefs about students' ability, the nature of science (NOS) and how scientists work may create barriers to the implementation of inquiry-based instruction (Keys & Bryan, 2001; Abd-El-Khalick *et al*., 2004; Wallace & Kang, 2004). These authors caution that some variables such as necessity to cover the curriculum, preparing students for examinations and keeping the science classroom efficient must be considered if inquiry-based instruction is to be fostered.

According to Kang and Wallace (2005), teachers who have naïve epistemological beliefs tend to use teacher-centered instructional practices. Teachers having naïve epistemological beliefs are those who hold traditional beliefs about the nature of science and scientific inquiry. Such beliefs include the ideas that science is an objective body of knowledge developed through a certain "scientific method" which is followed by all practicing scientists; observations are not influenced by the observer's preconceptions; and science is best taught by transferring knowledge from the teacher to the student. On the contrary, teachers who have sophisticated epistemological beliefs

are those who subscribe to views that scientific knowledge is tentative; observations are influenced by the observer's preconceptions; there is no one "scientific method" followed by scientists to develop scientific knowledge; students participate actively in knowledge construction; and prior knowledge plays an important role in new knowledge construction.

Some researchers believe that if designed properly, laboratory activities have the potential to develop students' conceptual and procedural knowledge and skills in science (for example Bybee, 2000). Contrary to this belief, research has revealed that there is a mismatch between teachers' instructional goals and epistemological beliefs, and their laboratory practices (Gardiner & Farrangher, 1999; Hodson, 2001; Kang & Wallace, 2005). Tan (2008) argues that most laboratory tasks are designed to make students follow step by step instructions instead of making their own decisions. He goes on to say that the tasks are used to illustrate and reinforce theoretical concepts that have been covered in class and to provide an opportunity for students to practice standard laboratory procedures for examination purposes. According to Tan, open-ended exploratory laboratory activities are generally less preferred than verification laboratory activities.

1.6 Chapters Organization

Chapter 1: Introduction to the study

This chapter provides an outline of the general background of the study. It outlines the purpose of the study including the research questions. The theoretical framework informing and guiding this study was discussed and the literature that is relevant to this study was also briefly examined. Ethical issues were also outlined in this chapter.

Chapter 2: Literature Review

This chapter gives a detailed review of the literature related to this study. Issues that are discussed include defining laboratory work, looking at the aims of laboratory work, research related to teachers' perceptions of aims of laboratory work and use of laboratory work, and research related to a link between teachers' perceptions and their instructional practices.

Chapter 3: Research Methodology

In this chapter, the design and the actual methods used in undertaking the study are discussed. The research instruments that are used, their justification, and administration are discussed. The issues of validity and reliability regarding the research instruments and data collection procedures are also discussed.

Chapter 4: Results and Discussion.

This chapter presents and discusses the results obtained for this study. The results are discussed under the three research questions; teachers' perceptions of the aims of laboratory work, teachers' use of laboratory work, and relationship between perception and use of laboratory work.

Chapter 5: Conclusions, Implications, and Recommendations.

This chapter describes the conclusions made from the study by responding to the three research questions which were designed to achieve the purpose of the study. Implications and recommendations are raised.

1.7 Conclusion

Chapter 1 has given a brief overview of the purpose of the study, the theoretical framework that informed and guided the study, and the research methodology that has been used to conduct the study. In the next chapter the literature relevant for the study is discussed.

Chapter 2

Literature Review

2. Introduction:

In this chapter, the literature related to this study is reviewed under the following headings: perspectives on laboratory work, historical overview of laboratory work, aims of laboratory work, inquiry and non-inquiry laboratory instruction; research on teachers' perceptions of the aims of laboratory work, research on teachers' use of laboratory work, and relationship between teachers' perceptions and their instructional practices.

2.1 Perspectives on laboratory work

Laboratory work is a very broad term which cannot be defined in a single statement as though it entails a single category of activity (Hodson, 2005). According to Hodson (2005), laboratory work consists of a wide variety of activities which can be used to make students understand laboratory work. Isaacs (1980) cited by Poliah (1993:8) defines laboratory work as:

> "…all kinds of observational, investigational and experimental activities in science teaching. It includes teacher demonstrations, student demonstrations, individual or group demonstrations and field investigations irrespective of whether they are merely routine repetitive exercises used to verify known facts or exercises designed to steer the class through the finding-out process and then to discover the answers. These activities may take place in the laboratory or elsewhere".

The above definition is based on the perspective of the types of laboratory work activities that students may undertake in a laboratory and the general organization of the students as they engage in such activities; these activities may require students to make observations, to carry out investigations, and to conduct experiments to solve problems which are science related. According to Hart, Mulhall, Berry, Loughran and Gunstone (2000) observation is not a passive reception of information, but involves cognitive processing by the observer. Hart *et al.* (2000)

argue that observation is dependent on the observer's expectations and the theoretical frameworks they hold, as a result people observe things differently. Domin (1999) describes an investigative activity as an inquiry-type activity which requires students to generate a problem, relate the investigation to previous work, state the purpose of the investigation, predict the results, design investigative strategies, and conduct the investigation. With regard to experimentations, Yildiz, Akpinar, Aydogdu and Ergin (2006) assert that science experiments provide effective ways through which students could acquire science concepts and learn the scientific method.

According to Hofstein (2004) laboratory work may be defined in the perspective of the phases of performance through which it progresses in a science laboratory. The first phase is *planning and design* which involves formulating questions, predicting results, formulating hypothesis, and designing experimental procedures. The second phase is *performance* in which students conduct the experiment, manipulate materials and equipment, make observations and record their findings. *Analysis and interpretation* comes as the third phase. Here, students process data collected, explain relationships, make generalizations, and formulate new questions based on the investigation. Finally is the *application phase* which involves making predictions, formulating hypothesis from results obtained and applying laboratory techniques to new experimental situations. Although Hofstein (2004) associates these phases of laboratory work with chemistry, they may as well be applicable in other science areas.

Millar (2004: 2) defines laboratory work as "…any teaching and learning activity which involves at some point the students in observing or manipulating real objects and materials". This definition implies that the teacher may perform an activity which provides the student with an opportunity to develop observation skills, such as in a demonstration. According to Johnstone and Al-Shuaili (2001) a scientific observation is a cognitive process which has both purpose and a theoretical perspective. Millar (2004) also includes students' manipulation of equipment and materials in the laboratory, which results in developing students' manipulative skills. Students' manipulation may involve both "hands-on and minds-on" activities, where students ask questions, suggest hypothesis, and design investigations (Hofstein & Lunetta, 2004). The

definition given by Millar is much similar to the definition given by Hofstein and Lunetta (2004: 31) who define laboratory work as: "Learning experiences in which students interact with materials and/or models to observe and understand the natural world" In both the above definitions, the authors lay emphasis on making observations and interacting with or manipulating materials when students construct scientific knowledge. This suggests that science educators regard the development of students' process skills as an integral part of laboratory work.

Pekmez, Johnson and Gott, (2005) contend that laboratory work can be defined in terms of the approaches followed towards its execution. These three approaches are described according to Pekmez *et al.* (2005) as follows: 1. The discovery approach perceives laboratory work as a learning experience that helps students find things for themselves, thus developing students' thinking. 2. The process approach sees laboratory work as experiences that help students learn the methodology of science not science content. 3. The investigative approach sees laboratory work as problem solving activities which require students to draw on substantive and procedural knowledge. Learning the methodology of science was thought to be practicing what scientists do when they are being scientists. However there has been some debate on whether there is a possibility of learning the methodology of science without incorporating science content (Hodson, 1996). The processes identified were classified into *basic processes or skills* (observing, measuring, inferring, predicting, classifying, collecting and recording data) and *integrated processes* (interpreting data, controlling variables, defining operationality, and formulating hypothesis).

Abrahams and Millar (2008:1) define laboratory work as: "activities in which students manipulate and observe real objects and materials". Abrahams and Millar (2008) argue that laboratory work has always been seen as an effective teaching and learning strategy in school science. The comment made by the House of Commons and Technology Committee (2002), paragraph 40, supports their argument:

> In our view, laboratory work, including field work, is a vital part of science education. It helps students develop their understanding of science, appreciate that science is based on evidence and

acquire hands-on skills that are essential if students are to progress in science. Students should be given the opportunity to do exciting and varied experimental and investigative work.

The above definitions show that science educators view laboratory work from various perspectives. In this study laboratory work is taken to mean all instructional activities done by the teacher, the teacher together with the students, or by the students working on their own, either individually or in groups in order to accomplish experiments, to demonstrate or to illustrate a scientific phenomenon (Vhurumuku, 2004). These activities may be done inside or outside the classroom/laboratory. Laboratory activities may be dichotomized as experimental and non-experimental activities. Experimental activities might follow a particular traditional method in which the aim of the experiment is specified, the procedure is provided, the results obtained are presented and perhaps interpreted, and a conclusion is made based on the aim of the experiment. They could also be investigative in nature. Non-experimental activities involve activities in which students develop scientific process skills, such as using microscopes to observe microorganisms and scientific instruments to measure quantities such as time, mass, length, and temperature. Whether the laboratory activities are experimental or non-experimental, observations and manipulation of objects and materials are very essential.

2.2 Historical Overview of Laboratory Work

Hodson (1993) reports that laboratory work can be traced as far back as the nineteenth century during which laboratory work played a supportive role of confirming the theory that had already been taught. According to Hodson teacher demonstrations were considered more important than individual experimentation by students. Hofstein and Lunetta (1982) argue that the laboratory in the science classroom has long been used to engage students in concrete learning experiences to the extent that some science educators such as Griffin (1892) claimed that their children would leave laboratories able to see and do. In the later years of the century, the rationale for laboratory work is reported to have shifted from the development of general learning skills to teaching the scientific method. Jenkins (1998) reports that laboratory work in the USA was used primarily to develop reasoning skills, encourage observation, and provide direct contact with the physical world, whereas in Britain laboratory work was mainly used for confirmatory purposes and

formal observational tasks. Hodson (1993) reports that many educators, John Dewey in particular, advocated investigative approaches to science teaching through problem solving, also emphasizing science learning by 'doing science'. However, Hofstein and Lunetta (1980) explain that poor laboratory facilities became a barrier to individual laboratory work and teachers resorted to teacher demonstration. Hofstein and Lunetta further indicate that during this time there was much debate about the proper role of laboratory work developed, and the following arguments were put forth: That few teachers in secondary schools were competent to use the laboratory effectively; too much emphasis on laboratory activity lead to a narrow conception of science; too many experiments performed at school were trivial; and that laboratory work in schools was often remote and unrelated to the capabilities and interests of the children.

According to Hodson (1993) during the major curriculum reforms of the 1960s, the discovery approach was developed, which was considered a more appropriate teaching style in comparison with the previous approaches. This approach was summarized as follows:

> The laboratory program was designed (1) to help students gain a better understanding of the nature of investigation by emphasizing the 'discovery approach' and (2) to give students an opportunity to observe chemical systems and to gather data useful for the development of principles subsequently discussed in the text or class work (Hodson, 1993: 87).

Jenkins (1998) reports that following the discovery approach was the development of the Nuffield schemes in biology, chemistry, and physics which were based on the inquiry approach in the teaching of science. In this approach students collected data from which generalizations would emerge, and further engaged in discussions leading to concept formation and understanding. Jenkins further argues that the inquiry approach was considered very important for promoting understanding and development of skills and techniques of scientific inquiry as opposed to promoting the acquisition of conceptual knowledge by the discovery approach. Hofstein and Lunetta (2004:248) report that during the major science education curriculum reforms in the early 1960s, laboratory work in science education was used to engage students in investigations, discoveries, inquiries and problem-solving activities. In their opinion, the laboratory was considered the centre of science teaching and learning.

2.3 Aims of Laboratory Work

Hofstein (2004) contends that science education is under reform, and that science educators strive to identify the actual role and practice of laboratory work in teaching and learning science. According to Hofstein research has failed to show how laboratory experiences are related to science learning. However, Hofstein (2004) acknowledges that there is sufficient evidence that laboratory instruction is an effective way through which some of the goals for teaching science could be attained. He argues that well designed laboratory activities can stimulate students' knowledge construction, develop inquiry and problem solving skills, develop manipulative and observational skills, cooperative and communicative skills, and promote positive attitudes towards learning science.

Bennett (2005) reports that an early study on the aims of laboratory work was done by Kerr (1963). According to Bennett a survey of 700 teachers was undertaken in which the teachers were given a list of ten possible aims of laboratory work to rank in order of importance starting with the most important (1) to the least important (10). Table 2.1 below is a summary of the 10 aims of laboratory work and the teachers' responses in the order of perceived importance (from Abrahams & Saglam, 2009: 3).

Table 2.1: Teachers' responses on aims of laboratory work in order of perceived importance (adapted from Kerr, 1963: 27).

Order of importance of the aims of laboratory work			
	Physics teachers		
Aims of laboratory work	Years 1-2	Years 3-5	6th form
1. To encourage accurate observation and careful recording.	5	4	1
2. To promote simple, commonsense, scientific methods of thoughts.	4	3	4
3. To develop manipulative skills.	7	8	6
4. To give training in problem solving.	9	9	8
5. To fit the requirements of practical examinations regulations.	10	10	10
6. To elucidate the theoretical work so as to aid comprehension.	6	2	2
7. To verify facts and principles already taught.	8	7	5
8. To be an integral part of the process of finding facts by investigation and arriving at principles.	3	1	3
9. To arouse and maintain interest in the subject.	1	5	9
10. To make biological, chemical and physical phenomena more real through actual experience.	2	6	7

Bennett (2005) reports that the teachers believed that the major aims of laboratory work were: To encourage accurate observation and description; to make scientific phenomena more real; to enhance understanding of scientific ideas; to arouse and maintain interest; and to promote a scientific method of thought. He goes on to indicate that new lists of the aims of laboratory work were developed where the feeling was that the existing aims of laboratory work lacked clarity. For example, Woolnough and Allsop (1985) suggested that the aims of laboratory work could be classified into three categories: 'To develop practical scientific skills and techniques'; 'to be a problem solving scientist'; and 'to get a feel for phenomena'. Following this classification, Hodson (1993) also suggested five categories of the aims of laboratory work: To motivate pupils by stimulating interest and enjoyment; to teach laboratory skills; to enhance the learning of scientific knowledge; to give insight into scientific method and develop expertise in using it; to develop certain scientific attitudes such as open-mindedness, objectivity and willingness to

suspend judgment. A more recent categorization of the aims of laboratory work has been suggested by Millar (2004). According to Millar (2004), the major aims of laboratory work are to develop conceptual understanding, students' interest and motivation, process skills and techniques, the nature of science and scientific inquiry. As said in Chapter 1, this categorization of the aims of laboratory work suggested by Millar (2004) was adopted for this study. According to Hofstein and Lunetta (2004: 248) the aims of laboratory work can be summarized into four main areas: To foster knowledge of the human enterprise of science so as to enhance student intellectual and aesthetic understanding; to foster science inquiry skills that can transfer to other spheres of problem-solving; to help the students appreciate and in part emulate the role of the scientist; and to help the students grow both in appreciation of the orderliness of scientific knowledge and also in understanding the tentative nature of scientific theories and models . This categorization is more or less the same as Millar's (2004).

2.4 Non-inquiry and inquiry oriented laboratory instruction

As indicated in the previous chapter, laboratory instruction is dichotomized as non-inquiry instruction and inquiry instruction (Domin, 2007). According to Domin non-inquiry style of instruction is the most predominant in school science and it is commonly referred to as traditional, expository or cookbook instruction because it relies much on laboratory manuals or laboratory worksheets where students follow a prescribed procedure to complete a given activity. Expository instruction is seen as a teacher-centered instructional style which follows a deductive approach (Domin, 1999). To Domin (1999, 2007) in a deductive approach, students are exposed to a general principle, and then experience specific cases or scenarios where the principle applies. This activity is intended to promote students' conceptual development of knowledge previously acquired, and students are often required to answer post-laboratory questions. According to Hofstein and Lunetta (2004) the laboratory manual or worksheet focuses students' attention on the questions to be investigated and on what is to be done, observed, interpreted and reported. Domin (1999) asserts that expository instruction provides a detailed procedure which is followed by students to arrive at an outcome, predetermined to both the teacher and the students. Hodson (2005) points out that it is this detailed procedure that makes students miss the objective of the given task as they concentrate much on the step by step instructions they should follow in

the procedure. The results that students obtain are compared with the expected theoretical results. In cases where the students' results differ from the expected results, students may be instructed to discard them and use the results of other groups. For this reason students spend much time on getting the expected results rather than thinking on designing and conducting the experiment (Domin, 1999). Furthermore, expository instruction is often criticized for engaging students in lower cognitive levels of Bloom's taxonomy of educational objectives; - knowledge, comprehension, and application.

Abd-El-Khalick *et al*. (2004) have pointed out that both inquiry instruction and constructivism emphasize that students learn by constructing their own knowledge as they interact with the physical and social laboratory environment. It is therefore expected that teachers should use student-centered instructional approaches in which teachers take the role of learning facilitators instead of disseminators of knowledge (Mamlok-Naaman & Hofstein, 2004). Inquiry oriented laboratory instruction is basically a collection of three instructional styles; guided inquiry (discovery), open inquiry, and problem solving (Domin, 1999, 2007).

Guided inquiry follows an inductive approach in which students make several observations and analyses of specific phenomena from which a general principle is derived. This style of instruction is important for developing an understanding of scientific concepts and principles (Domin, 2007). Guided instruction is similar to the traditional expository instruction in that the procedure is given. However, the outcome of the laboratory activity may either be known to both the teacher and students, or to the teacher only. The teacher provides minimum guidance to the students so that they may discover the desired outcome (Domin, 1999, 2007). Guided inquiry instruction has not gone without criticisms. Hodson (1996) has argued that this style of instruction is pedagogically unworkable. He emphasized that students cannot discover something that they are not conceptually prepared for, because they will not be able to look for this unknown, let alone recognizing when it is found. Hodson also pointed out that it is not appropriate to call this instruction "discovery" since the teacher gives students guidance toward arriving at the desired outcome.

Open inquiry instruction gives students a higher degree of independence than guided inquiry, and students develop a sense of ownership of the laboratory activity. In this style of instruction the outcome is undetermined to both the teacher and the students. The procedure is not given, but students generate their own. For this reason, Domin (1999) argues that open inquiry instruction develops students' critical thinking and creativity. He further argues that if used properly, open inquiry instruction can develop students' inquiry skills such as formulating hypothesis, designing and conducting investigations and experiments, making observations and measurements, collecting and analyzing data, and making conclusions.

In problem solving instruction, the teacher gives students a question or a problem. Problem solving instruction follows a deductive approach in which the students use previously acquired knowledge to solve the problem. Successful problem solving is dependent on students' good understanding of the underlying scientific concepts and principles. Science educators argue that teachers should pose open ended real-life problems that raise students' curiosity and that match their level of understanding in order to avoid discouraging them (Akinoglu & Tandogan, 2007). Science educators see problem solving as good for developing testable hypothesis rather than obtaining correct results, developing students' problem solving skills, high level thinking, and scientific thinking (Domin, 1999; Akinoglu & Tandogan, 2007).

2.5 Research on Teachers' Perceptions of the Aims of Laboratory Work

Recently, Abrahams and Saglam (2009) conducted a study to examine whether there had been any changes in the relative importance of the aims science teachers assign to laboratory work, across the full secondary school range, since Kerr's study (1963). Abraham and Saglam (2009) posted 912 questionnaires to science teachers in England and Wales, to rank 10 aims of laboratory work derived from Kerr's study (1963), according to their order of importance from (1) most important to (10) least important. Only 388 questionnaires were received from the teachers and 363 were analyzed. Table 2.2 below shows a comparison of the students' age ranges that were used for the study by Kerr (1963) and the study by Abrahams and Saglam (2009). The age ranges in the study by Abrahams and Saglam (2009) are referred to as Key Stages (KS) according to curriculum structure in the U.K

Table 2.2: A comparison of the age ranges used in both studies

(adapted from Abrahams & Saglam, 2009: 5)

Study	Youngest range	Middle range	Oldest range
Kerr (1963)	Years 1-2	Years 3-5	6th form
	Aged 11-13	Aged 14-16	Aged 17-18
Abrahams and Saglam	Years 1-3(KS3)	Years 4-5(KS4)	6th form(KS5)
(2009)	Aged 11-14	Aged 15-16	Aged 17-18

The findings were that there were changes in teachers' perceptions of the aims of laboratory work in the Key Stages 4 and 5 (KS 4 & 5), which constitute students in the age range from 15 to18 years while there were no changes in Key Stage 3(age 11-14) (see table 2.2 above). These results were found to be similar across subject specializations, teacher gender and years of teaching experience.

Lynch and Ndyetabura (1983) conducted a study to establish a relative order of importance of aims of laboratory work as perceived by practicing teachers. Questionnaires were administered to 257 science teachers in Tasmanian schools (Grades 7-11). The teachers were given ten possible aims of laboratory work and asked to choose any four which they considered the most important. The results showed that all the teachers believed that the following aims of laboratory work as the most important: To interpret observations logically; to make theory more real and interesting; and to give training in skills and techniques. The following aims were considered unimportant by all teachers: To teach how to conduct laboratory experiments in an organized way; to prepare students directly for final examinations; to give a personal interest in practical work and experimentation; and to encourage the study of science or related subjects further after leaving school. Lynch and Ndyetabura (1983) found that the teachers' perceptions showed little change throughout the classes and therefore concluded that teachers' perceptions of the aims of laboratory work appeared to be misguided or misjudged.

Wilkinson and Ward (1997) conducted a study comparing teachers' and students' perceptions of the aims of laboratory work, regularity, conduct, and assessment of laboratory work at year 10

level of secondary school in Australia. The teachers and their students were given questionnaires with a list of ten aims of laboratory work derived from a previous study (Lynch & Ndyetabura, 1983) to rank them in order of most important (rank 1) to least important (rank 10). Although a mismatch was found between teachers' and students' perceptions of the aims of laboratory work, both teachers and their students believed that laboratory work was important for promoting understanding of theory. Similar results were obtained from a study by Jenkins (2000) investigating the impact of a new curriculum on teachers' work in England and Wales, teachers held a view that laboratory work was important for backing up theoretical work.

Another comparative study was undertaken by Swain *et al.* (1999) in which they were investigating teachers' attitudes to laboratory work, from Egypt (n=54), Korea (n=35) and the U.K (n=66). Swain *et al.* (1999) used a questionnaire developed by Beatty and Woolnough (1982) consisting of 20 aims of laboratory work in which teachers rated each of the aims on a four Likert scale where (1) was least important and (4) was most important. The results showed a significant difference in the ways in which teachers from these countries conducted laboratory work. Korean teachers appeared to be using laboratory work that was content focused, the U.K teachers, investigative, while Egyptian teachers appeared to be doing very little laboratory work. Analysis of the conditions in which these teachers worked revealed that the U.K teachers had well equipped laboratories, while Korean teachers had satisfactory laboratories compared to the Egyptian teachers, whose laboratories were poorly equipped. Swain *et al.* (1999) concluded that the selection of laboratory instructional practices is influenced by the teaching conditions in which teachers find themselves.

Pekmez *et al.* (2005) undertook a study in which they were examining teachers' perceptions of the nature and purpose of laboratory work in the context of the National Curriculum for Science in England. Data was collected from 25 participating teachers using structured individual interviews and non-participant observations. The interview guide covered the following three areas: the purposes of laboratory work, types of laboratory work, and questions on particular instances. The teachers believed that there were four main aims of laboratory work: reinforcement of theory to enhance students' understanding, development of laboratory skills,

promotion of collaborative skills, and motivation of students. In another study by Ottander and Grelsson (2006) teachers indicated that the aims of laboratory work were to confirm theory, motivate students, teach laboratory skills and techniques, and to confront and challenge students' misconceptions. However the teachers believed that the most important aims of laboratory work were to promote students' understanding of theory and to stimulate students' interest in science.

2.6 Research on Teachers' Use of Laboratory Work

Staer, Goodrum and Hackling (1998) administered a questionnaire to 197 junior secondary science teachers in Australia to determine the openness to inquiry of laboratory activities. The level of openness was determined with a scale developed by Hegarty-Harzel, 1986, cited by Staer *et al.* (1998), shown in Table 2.1 below.

Table 2.3: Levels of openness to inquiry in laboratory activities by Hegarty-Hazel, 1986 (adapted from Staer *et al.,* 1998).

Level	Problem	Apparatus	Procedure	Answer	Common name
0	Given	Given	Given	Given	Verification
1	Given	Given	Given	Open	Guided inquiry
2a	Given	Given	Open	Open	Open guided inquiry
2b	Given	Open	Open	Open	Open guided inquiry
3	Open	Open	Open	Open	Open inquiry

Staer *et al.* (1998) found that 84% of the laboratory activities were either at level 0 (verification) or level 1 (guided inquiry) with only 16% of the activities allowing students the opportunity to engage in problem solving and investigative laboratory work. Hofstein and Lunetta (2004) argue that a well designed laboratory activity focused on inquiry offers students the opportunity to develop investigative skills, and to make justifiable scientific claims through interaction with their teachers in a laboratory environment. However, according to Hofstein and Lunetta (2004) and Hodson (2005) there is often a mismatch between what is required by the curriculum and teachers' classroom practices. Hofstein and Lunetta (2004: 47) put it succinctly as follows:

> …Clearly serious discrepancies exist between what is recommended for teaching in the laboratory-classroom and what is actually occurring in many classrooms…. Reluctance may also originate in the beliefs teachers hold about what students should be learning in laboratory experiences, how students learn, what they need to do to achieve important learning outcomes, and what they need to perform successfully on external examinations…

Research has revealed that there are impediments to the use of inquiry approaches to teaching science which do not only affect laboratory instruction but students' learning as well. These impediments were identified as lack of resources, management problems, prescribed curriculum, teacher beliefs about the nature of science, teaching and learning, time constraints, and safety issues (Wilkinson & Ward, 1998; Keys & Bryan, 2001; Tsai, 2002; Wallace & Kang, 2004; Al-Naqbi & Tairab, 2005; Cheung, 2007). It is believed that these impediments influence instructional practices in such a way that teachers resort to the implementation of non-inquiry instruction and/or reduction of laboratory work.

In another study, Ottander and Grelsson (2006) examined teachers understanding of the role of laboratory work. Four experienced teachers involved in a project on assessment of laboratory work participated in the study. The sources of data were questionnaires, semi-structured interviews, laboratory sheets and laboratory observations. Laboratory worksheets were analyzed on the basis of five assessment skills of laboratory work according to Swedish national standards. These skills were (1) planning experiments, (2) carrying out experiments, (3) interpretation of results, (4) evaluation of results, and (5) presentation of laboratory work. The teachers expressed that they abandoned assessment of laboratory work with the reason that it was time-consuming. It was also found that performance assessment was not incorporated into students' final assessment mark. Analysis of the laboratory worksheets showed that laboratory tasks focused entirely on skills (2) to (5) totally neglecting planning of experiments (1).

2.7 Research on interaction between teachers' perceptions and instruction

Many studies in the literature (for example, Tsai, 2002, 2007; Wallace & Kang, 2004; Kang & Wallace, 2005) have focused on the relationship between teachers' epistemological beliefs and

their instructional practices. From the reviewed literature no research has looked at the relationship between teachers' perceptions of the aims of laboratory work and their instructional practices. However, some studies found that teachers' beliefs about the nature of science, teaching science, and learning science, are closely correlated (for example, Tsai, 2002). For example, teachers holding a perception that science learning requires deep understanding of theory, tend to give a lot of science content which is followed by laboratory work intended to confirm or verify the theory. In other words, teachers' perceptions of the aims of laboratory work seem to be inherent in teachers' epistemological beliefs, and are reflected in teachers' instructional practices as well.

Hashweh (1996) undertook a study to investigate the effects of science teachers' epistemological beliefs in teaching. In this study, he used a questionnaire to classify 35 Palestinian science teachers into; knowledge constructivists, learning constructivists, knowledge empiricists, and learning empiricists according to their responses. According to Hashweh (1996) knowledge constructivists believed that observations are theory-laden, scientific knowledge is tentative and develops through a series of revolutions. On the other hand, knowledge empiricists believed that scientific knowledge is objective, discovered through a universal scientific method, and develops through accumulative growth. Hashweh also indicated that learning constructivists held views that learning is an active process of knowledge construction which involves conceptual change. In contrast to learning constructivists, learning empiricists emphasized knowledge transmission and did not recognize students' prior knowledge, and the existence of alternative conceptions. Hashweh found that constructivist teachers employed a constructivist approach in their teaching such as recognizing students' preconceived ideas, while empiricist teachers employed an empiricist approach which emphasizes teaching the scientific method. He therefore concluded that teachers' epistemological beliefs influence their instructional practices.

Kang and Wallace (2005) conducted a study to investigate how secondary science teachers' epistemological beliefs and instructional goals influence their use of laboratory activities. Three experienced high school teachers participated in this study. Data were collected using interviews, laboratory observations, and instructional materials (students and laboratory worksheets). The

findings showed that teachers' naïve epistemological beliefs were consistent with their instructional practices, whereas teachers' sophisticated epistemological beliefs were rarely reflected in their instructional practices. Wallace and Kang (2004) are of the view that teachers' classroom practices are representative of their beliefs. Naïve epistemological beliefs and sophisticated epistemological beliefs are what Hashweh (1996) refers to as empiricist and constructivist epistemological beliefs. Findings similar to those obtained by Kang and Wallace (2005) were also found by Tsai (2007). Teachers with constructivist-oriented scientific epistemological views tended to use inquiry oriented instruction.

2.8 Conclusion

In reviewing the literature, different definitions of laboratory work were given as suggested by different authors. The historical overview has shown that laboratory work dates as far back as the nineteenth century when it was used for confirmation/verification purposes. Through development, the use of laboratory work shifted from verification to discovery and then to investigation. It has also been shown that teachers' perceptions of the aims of laboratory work are varied, but the predominant view is that laboratory work is important for understanding of theory. Science educators have suggested several major classifications of the aims of laboratory work. Research evidence on teachers' use of laboratory work indicated that teachers use laboratory work to verify scientific facts and principles. In chapter 3, the research design and methodology is discussed.

Chapter 3
Research Methodology

3. Introduction

In this chapter the research design and methodology are discussed under the following headings: research design; participants' sampling and demographics; research instruments; issues of validity and reliability; data collection procedures; and data analysis.

3.1 Research design

McMillan and Schumacher (2006) describe a research design as an outline of data collection methods including the procedures to be followed in analyzing data. This study used both quantitative and qualitative research approaches. A quantitative approach normally uses standardized instruments, such as questionnaires, to collect and analyze data. Data analysis can involve descriptive and/or inferential statistical techniques. Quantitative approaches produce figures, tables and graphs. They are concerned with the spread or frequency of an event or with the number of respondents holding a particular perception or view, or belief (Best & Kahn, 1998; McMillan & Schumacher, 2006). A qualitative `approach involves a "systematic collection, organization, and interpretation of textual material derived from talk or observation" (Malterud, 2001:483). Qualitative research is about getting deeper insights into the nature of phenomena, and is interpretive.

This study combined a survey with in-depth study of selected cases. According to Fraenkel and Wallen (1990) the purpose of a survey is to describe the characteristics of a population. Such characteristics include attitudes, beliefs, values, demographics, behavior, opinions, habits, desires, and ideas (McMillan & Schumacher, 2006). A survey was considered appropriate for this study because it allowed the researcher to find out, generally, the teachers' perceptions of the aims and use of laboratory work, and the teachers' laboratory instructional practices. This approach to studying teachers' and students' perceptions of aims of laboratory work has been used successfully in earlier studies (for example, Wilkinson & Ward, 1997; Lynch &

Ndyetabura, 1982). At the same time it was felt that a detailed study of a few selected cases would provide some deeper insights into the phenomena under consideration.

Data on teachers' perceptions of aims of laboratory work were elicited through: Likert type questionnaire called Teacher Perceptions of the Aims of Laboratory Work (TPALW- Appendix A); an open ended questionnaire (Appendix C); and semi-structured interviews (Appendix D). Teachers' use of laboratory work and their instructional practices were determined through a Likert type questionnaire called Teacher Perceptions of Instruction (TPI -Appendix B); an open-ended questionnaire (Appendix C), interviews (Appendix D**);** and classroom observations (Appendix E). It is important to note that the open ended questionnaire (Appendix C) consisted of questions eliciting information on both teachers' perceptions of the aims of laboratory work and their use of laboratory work when teaching.

Questionnaires were considered appropriate for collecting data because they are relatively economical in terms of both time and money (McMillan & Schumacher, 2006). According to McMillan and Schumacher (2006) questionnaires provide similar questions to a larger sample of participants compared to other techniques, and also allow adequate time for the participants to think about responses. McMillan and Schumacher also point out that the element of anonymity is best ensured with a questionnaire than with other data collection techniques. The use of interviews has been recommended for allowing flexibility of the interviewer (Ary, Jacobs & Razavieh, 1990) and providing an in-depth understanding of perceptions and interviewees conceptions of chosen phenomena (Opie, 2004; Burton, Brundrett & Jones, 2008). For this study, semi-structured interviews were selected because they provide the researcher with opportunities for probing in order to clarify answers and to encourage elaborate responses (Fraenkel & Wallen, 1990; McMillan & Schumacher, 2006). Observations are highly recommended for data collection because they offer the researcher the opportunity to gather first hand data from natural settings (Cohen *et al*. 2000). Borg and Gall (1983) argue that if used properly, observations overcome bias that is inherent in self-reports, such as in questionnaires and interviews. It is also argued that observations allow the researcher to discover things that participants cannot freely talk about in interview situations (Cohen *et al*., 2000).

Data from the Teacher Perceptions of the Aims of Laboratory Work (TPALW) were analyzed quantitatively by generating frequencies and interpreting the results, whereas data from the Teacher Perceptions of Instruction (TPI) were analyzed by assigning scores to teachers' responses and finding the total score for each teacher (minimum 25 and maximum 125), and finding the median to classify teachers' instructional practices into expository (lower scores: 25-74) and non-expository (higher scores: 75-125). Open-ended questionnaire and interview data were analyzed through a combination of typological analysis (Hatch, 2002) and interpretational analysis (Gall, Borg & Gall, 1996). According to Hatch (2002) typological data analysis involves categorization of text segments under predetermined typologies derived from theory, whereas interpretational analysis (Gall et al., 1996) involves giving meaning to data by generating explanations. Figure 3.1 below shows a summary of the methodological framework (n = 50).

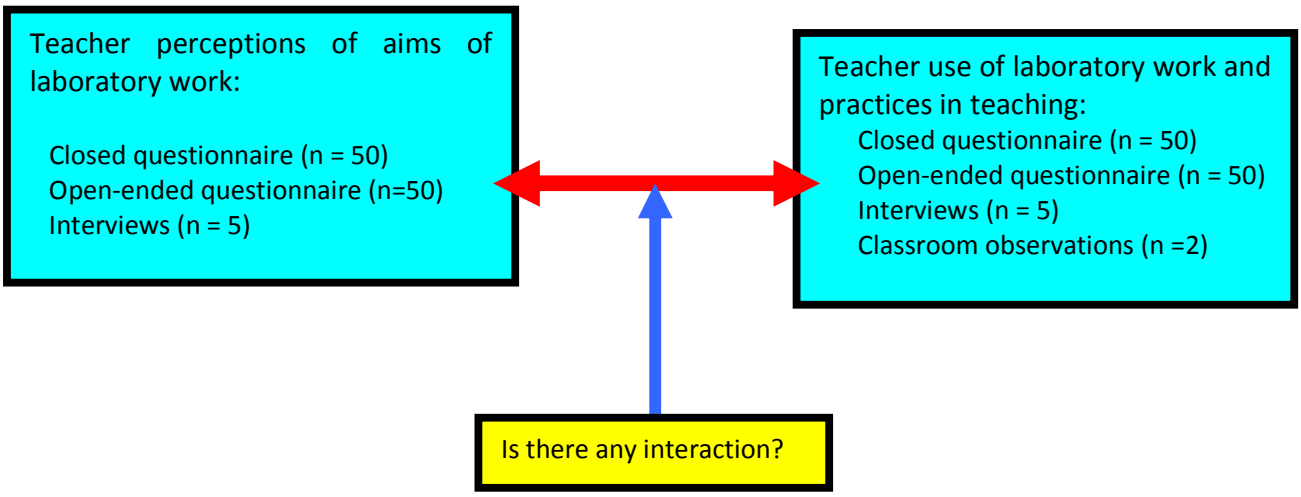


Fig. 3.1: Summary of methodological framework

3.2 Participants' sampling and demographics

Convenience sampling (Gall *et al.* 1996) was used to select teachers who participated in this study. Convenience sampling was chosen because the schools are in the district where the researcher is living, and it was seen as making economic sense. However, there are disadvantages associated with convenience sampling; it has a high potential for bias, and it is not

considered representative of the entire population, hence it is not generalizable beyond the study sample (Fraenkel & Wallen, 1990). To minimize potential bias an attempt was made to cover all junior secondary schools of the Butha-Buthe district, although this attempt was not successful for reasons beyond my control.

Fifty junior secondary science teachers from 12 schools out of a pool of 16 schools in one of the districts of Lesotho participated in this study. Although the intention was to cover all the schools, one of the remaining schools closed before the researcher could get to the teachers whereas the other three schools were too far and the means of transport were not reliable. Out of the fifty teachers, 18 (36%) were females and 32 (64%) were males. The majority of these teachers (90%) were specialized to teach science while 10% of them were teaching outside their areas of specialization. The average teaching experience for these teachers was 6.5 years. The teachers' academic qualifications are shown in Table 3.1 below.

Table 3.1 Teachers' academic qualifications

Academic qualification	Number of teachers	% Frequency
Secondary Teachers Certificate & Diploma in Science Education	16	32
B Sc / B Sc Ed	27	54
M Ed / M Sc Ed	3	6
Not indicated	4	8

3.3 Research instruments

This section describes and explains the instruments used in this study. These instruments are: Teacher Perceptions of the Aims of Laboratory Work (TPALW) Questionnaire (Appendix A); Teacher Perceptions of Instruction (TPI) Questionnaire (Appendix B); an open ended questionnaire (Appendix C), a semi-structured interview schedule(Appendix D), and laboratory observation schedule(Appendix E).

3.3.1 Teacher Perceptions of the Aims of Laboratory Work (TPALW) Questionnaire

The Teacher Perceptions of the Aims of Laboratory Work (TPALW) questionnaire was adapted from Wilkinson and Ward's (1997) study. Wilkinson and Ward used this questionnaire to investigate teachers' and students' perceptions of the aims of laboratory work. The adapted questionnaire consisted of three sections; A, B and C. Section A required the teachers to provide demographic information on: gender; age; teaching experience; qualifications, classes taught; and subjects of specialization. These variables were considered essential for describing the characteristics of the participants, and important for exploration of their possible link to the investigated perceptions. Section B of the questionnaire, required the teachers to indicate how important they thought each of the ten given aims of laboratory work was. They were required to indicate whether they thought each of the ten aims was; "Not Important", "Important" or "Very Important", by ticking (√) in the appropriate box (Appendix A). Some examples of the aims given in the questionnaire are:

1. To gain practice at making accurate observations and interpreting them

5. To help students understand theoretical parts of science

10. To develop an understanding of the nature of science

It is important to note that in the original design of the questionnaire, Wilkinson and Ward (1997) asked respondents to rank the 10 aims of laboratory work from 1 to 10, starting with the most important (1) to the least important (10). The idea of asking respondents to respond by indicating "Not Important", "Important" or "Very Important" was borrowed from Lynch and Ndyetabura (1983) who asked teachers and students to respond to ten aims of laboratory work in a similar manner. Lynch and Ndyetabura (1983) were comparing teachers' and students' perceptions of the aims of laboratory work. An additional change made to the Wilkinson and Ward (1997) instrument was that item 5, "to prepare students for examinations" in the original questionnaire was replaced by the item 10, "to develop an understanding of the nature of science". This was seen as important, in line with contemporary thinking about the importance

of developing students' ideas about the nature of science (see, Lederman, 1998; Millar, 2004; Vhurumuku, Holtman, Mikalsen & Kolsto, 2006).

In section C of the questionnaire the teachers were required to consider how important the given four major aims of laboratory work were. They were required to indicate whether they thought each of the four aims was: Not Important; Important or Very Important; by ticking (√) in the appropriate box (see Appendix A). The aims of laboratory work to be considered were: development of students' conceptual understanding of theory; promoting interest and motivation in science; development of science process skills and techniques; and development of understanding of the nature of science and scientific inquiry.

3.3.2 Teacher Perceptions of Instruction (TPI) Questionnaire

This questionnaire (Appendix B) was adapted from Abraham's (1982) study, originally designed to provide descriptive information about instructional methods and curriculum materials used in the science laboratory (Abraham, 1982). Although this instrument was designed to investigate verification, guided inquiry, and open inquiry laboratories, the researcher decided to use it to investigate inquiry laboratories and non-inquiry laboratories, with the intention to avoid complex analytic situations. Slight changes were made to the instrument so that it suited the context in which it was going to be used. For example, in statement 6 the word "instructor" in the original statement was replaced with the word "teacher" to suit the African classroom context. While the original statement read, "the instructor asks students to design their own experiments", the new statement read, "the teacher asks students to design their own experiments". The TPI consisted of 25 statements describing activities taking place in the laboratory. The sampled teachers responded to the questionnaire by ticking in the appropriate box on a Likert scale to indicate the extent to which they agreed with the given statement. The Likert scale ranged from *almost never, seldom, sometimes, often,* and *almost always.* Three examples of the statements are:

1. I ask students to follow step by step instructions in the laboratory guide or worksheet.

12. Laboratory reports require students to answer specific questions.

25. The teacher gives information to individual students in small groups.

To ensure anonymity the participants were instructed not to write anything on the questionnaire that could lead to disclosure of their identity, such as their names.

3.3.3 Open ended questionnaire (Appendix C)

This questionnaire (Appendix C) elicited information on both teacher perceptions of the aims of laboratory work and their use of laboratory work and teaching practices. The open ended questionnaire consisted of six questions. One question explored teachers' perceptions of the aims of laboratory work. This question was sourced from an interview schedule by Pekmez et al. (2005) based on a study investigating teachers' understanding of the nature and purpose of laboratory work. However the wording was slightly changed in order to make the question clearer and to encourage an elaborate response. The original question was: "What is the value of doing laboratory work?" The question used in this study was: "Do you think laboratory work is important for teaching science? Explain your answer".

The other questions elicited information on the regularity of laboratory work, adequacy of laboratory equipment and/or materials, the role and use of experiments, and the use of laboratory work respectively.

Two of the questions (4 and 5) were on teachers' use of laboratory work were sourced from an interview schedule by Kang and Wallace (2005) who explored teachers' epistemological beliefs and teaching goals and how they related to their use of laboratory activities. These questions are:

1. In your teaching, what do you use laboratory work for?
4. What do you think is the role and use of experiments in teaching science?

The participants were required to answer the questions in the spaces provided on the questionnaire.

3.3.4 Interview schedule

Semi-structured interviewing was used. The interview schedule (Appendix D) was divided into two sections. The first section elicited information on teachers' perceptions of the aims of

laboratory work. The second section elicited information on teachers' use of laboratory work, and their instructional practices. The questions in the interview schedule were sourced from interview schedules in the previous related studies (Kang & Wallace, 2005; Pekmez *et al.*, 2005) while other questions were included to get information on laboratory conditions under which the teachers were working. Below are some examples of questions that were asked in the interview schedule pertaining to teachers' perceptions of the aims of laboratory work? Probing and further questioning were made around these questions.

1. Can you say something about your experiences in using laboratory work (practical work) for teaching?
2. Almost all schools in Lesotho have a laboratory. Do you think it is necessary to have a laboratory at every school? Why or Why not?
3. What do you use laboratory work for? I mean what goals do you aim to achieve when you use laboratory work?
4. What do you think students can learn from doing laboratory work?
5. According to you what are the most important aims of laboratory work?

Below are examples of the core questions pertaining to teachers' use of laboratory work.

3. What problems do you normally encounter when using laboratory work for teaching?

4. How do you organize your laboratory activities? Group work or individual work? What is your role during laboratory activities?

5. In your opinion, what should teachers do to ensure successful use of laboratory work in teaching science?

7. Do your students sometimes design their own experiments? Do you think it is important that students design their own experiments? Explain.

3.3.5 Laboratory observation schedule

A semi-structured laboratory observation schedule (Appendix E) was designed to observe the teachers' actual laboratory practices. The observation schedule focused on specific events occurring during laboratory instruction guided by predetermined criteria obtained from the literature (Staer *et al*., 1998; Tsai, 1999; Hofstein, 2004; Wallace & Kang, 2004; Kang & Wallace, 2005). The observation was guided by the following:

- Aim of laboratory work
- Source of laboratory activities
- Aim of laboratory work activity
- Introduction, body and conclusion of the lesson
- Post laboratory exercises
- Questioning techniques
- Organization of laboratory activities
- Distribution of resources/materials
- Student-student and student-teacher interactions
- Approach used e.g. verification, discovery, problem solving, investigation
- Availability of resources
- Assessment and evaluation
- Reflection by teacher
- Post lesson interview

Spaces were provided on the observation schedule (Appendix E) for the researcher to record observations during the lesson.

3.4 Validity and reliability

In designing a research, one should be aware of issues relating to validity and reliability. Best and Kahn (1998) argue that validity and reliability are essential aspects of measurement in determining the effectiveness of any data-gathering instrument or procedure. This argument is

supported by McMillan and Schumacher (2006) who assert that reliability and validity are the two basic principles of measurement necessary for selecting appropriate data-gathering instruments and evaluating the effectiveness of data-gathering procedures. They define validity as "the extent to which inferences and uses made on the basis of scores from the instrument are reasonable and appropriate". McMillan and Schumacher identify two major types of validity; internal and external validity. According to McMillan and Schumacher (2006) internal validity refers to the design of a study to effectively eliminate extraneous factors that may influence the results of the study. They argue that external validity is a measure of the extent to which the results of a study can be generalized to other people or contexts. McMillan and Schumacher (2006:183) define reliability as "the consistency of measurement, or the extent to which the scores are similar over different forms of the same instrument or occasions of data collection, or the extent to which measures are free from error". A common way of estimating the reliability of instruments is the use of internal consistency, which is appropriate for instruments which are administered once and include items that are not scored right or wrong, such as questionnaires (McMillan & Schumacher, 2006). The reliability of an instrument can be increased by increasing the number of items of the same quality and administering the instrument in such a way that it is free from distractions and variations amongst the participants (Best & Kahn, 1998).

Although it was felt that the TPI questionnaire had established validity, it was given to 10 science education post graduate students at the University of the Witwatersrand to check on the clarity, appropriateness and comprehensiveness of the statements. At the bottom of the instruments some space was provided for comments on the improvement of the instrument. This instrument was validated through discussion with my supervisor prior to its implementation. From the discussion it was agreed that the instrument had construct validity, that is, it actually would elicit information on expository and inquiry oriented instructional practice. Suffice it to say that this instrument has been used successfully for this purpose (Vhurumuku, 2004).

The interview schedule and the observation schedule were validated by three science educators at the University of the Witwatersrand. For the interview schedule the science educators checked on whether the questions were not ambiguous and whether they would elicit the required information that would answer the research questions. For the observation schedule the science

educators checked on whether the observation guide was comprehensive, that is, included all the aspects of laboratory instruction that could be used to analyze teacher laboratory instructional practices. The two instruments were further validated through discussion with my supervisor before they were implemented in the main study.

3.5 Pilot study

Teijlingen and Hundley (2001) describe a pilot study as a pre-testing or trying out of a particular instrument such as a questionnaire or interview schedule, or a feasibility study, which is undertaken to identify potential practical problems in the implementation of the instrument or in following the research procedure in the main study. To check on the validity and reliability of the questionnaire (TPALW) a pilot study was performed. Opie (2004) shares the same opinion that undertaking a pilot study is quite essential in the design of research instruments before embarking on the major study. According to Opie, it is apparent that a pilot study is important for addressing issues of validity and reliability of research instruments. It is recommended that the research instruments be administered to pilot respondents with similar characteristics to the respondents in the main study, and in the same manner as it would be administered in the main study (Teijlingen and Hundley, 2001).

The questionnaire was administered to 10 science education post-graduate (B.Sc. Honours and M.Sc.) students in the School of Education at the University of the Witwatersrand. A test-retest reliability method of calculating internal consistency was used and a Cronbach's alpha reliability coefficient of 0.63 was obtained. According to Straub, Boudreau, and Gefen (2004) an acceptable Cronbach's alpha value, as a rule of thumb, should be above 0.60 for an exploratory research (one seeking an understanding into a given situation), such as the current research, while for a confirmatory research (one testing a particular assumption) the Cronbach alpha value should be above 0.70. This shows that this questionnaire was reliable and could be used successfully to gather information that is trustworthy.

In the light of the results of the pilot study, some questions seemed ambiguous and the wording was changed. The respondents were not familiar with some of the words, so the words were

replaced with familiar ones, for example, “instructor” replaced with “teacher” (TPI questionnaire). The instructions for responding to section B of the TPALW questionnaire seemed quite misleading so that analysis of the data would not be effective. In this case the instructions were changed from rating the ten given aims of laboratory work starting from 1(most important) to 10(least important) into a Likert scale where the respondents indicate with a tick whether each of the given aims of laboratory work were “not important”, important” and “very important” (TPALW questionnaire).

3.6 Data collection procedures

3.6.1 Questionnaires administration

Ethical principles demand that consent should be sought from institutions providing research facilities. As a result the researcher went to the schools to seek permission from the school principals to conduct the study in their schools. As a way of introduction a letter of authorization to conduct the study from the District Education Officer (Appendix I) was given to the principals. The two questionnaires; Teacher Perceptions of the Aims of Laboratory Work (TPALW) and Teacher Perceptions of Instruction (TPI) were issued to teachers, who were willing to participate in the study, during November 2008. The questionnaires were given to the teachers either by the principals or heads of departments, in some schools. In other schools the researcher was allowed to talk to the teachers before issuing them. The teachers completed the TPALW and the TPI questionnaires during their own time. Although the researcher had wanted to personally administer the questionnaires in the schools, such a desire was very difficult to achieve. Changing the normal procedure of completing questionnaires in the schools was beyond the control of the researcher. The questionnaires were collected after five days so as to give the participants sufficient time to complete the questionnaires. In all, 70 questionnaires (TPALW and TPI) were issued to the teachers and 54 questionnaires (TPALW and TPI) were collected. Fifty (50) of the collected questionnaires (TPALW and TPI) were used for this study. Four questionnaires were discarded because it was felt they were largely incomplete.

3.6.2 Semi-structured interviews -teachers’ perceptions and use of laboratory work

In this study the problems of cost and time were overcome through convenience sampling. Five of the teachers who completed the questionnaire were conveniently selected for semi-structured interviewing. These were teachers selected from schools along the main North 1 road from Maseru to Mokhotlong. The selection of these teachers also depended on their willingness to participate in the interviews. The semi-structured format was also used for increasing comparability of the responses since all the participants answer the same questions (Borg & Gall, 1983; Cohen *et al.* 2000). The problem of bias was minimized by audio-taping the interview proceedings so as to reduce the researcher's tendency to record data in his favour (Cohen *et al*., 2000).

The interviews of the five teachers were conducted in the laboratory at each of the selected schools in March 2009. In each of the five cases, the interviewee thought the laboratory was appropriate due to its quietness. The researcher was dressed in a manner similar to the interviewees, friendly, relaxed and pleasant in order to make the interviewees comfortable so that they became willing to provide honest responses (McMillan and Schumacher, 2006). Before the interview commenced, the researcher engaged the interviewee in a small talk in order to create a comfortable atmosphere and to establish a rapport with the interviewee (Cohen *et al.,* 2000). During preparations for the interview the researcher gave a brief explanation of the purpose of the interview to the interviewee to reduce the potential effect of the interview on the interviewee. During the interview simple questions were asked at the beginning to develop confidence in the interviewee. The questions in the interview schedule were asked in the same order to increase comparability of the teachers' responses (Cohen *et al.,* 2000; McMillan & Schumacher, 2006). The interviewees were allowed sufficient time to give their responses, and interrupting them was avoided lest they forget what they wanted to say. The researcher used probing techniques for further clarification of answers where necessary, to avoid the interviewers bias (Cohen *et al.,* 2000) also taking care not to affect the nature of the responses (McMillan & Schumacher, 2006). The interview data was audio-taped with consent from the interviewees. The audio-taping allowed for a smooth flow of the interview proceedings and increased accuracy and objectivity of the data collection (Cohen *et al.,* 2000). However, McMillan and Schumacher (2006) alert that the presence of an audio-tape may disrupt the interview especially when dealing with personal or sensitive issues. After the interview the interviewees were thanked for participating in the

interview and sacrificing their valuable time; which is highly recommended in interviews (Cohen *et al*., 2000).

3.6.3 Laboratory observations -teachers' use and practices in laboratory work teaching

Non-participatory classroom observations (Cohen *et al*. 2000) were conducted in March and April 2009. The purpose for using the observations was to triangulate data obtained from the close ended questionnaire (TPI) (Appendix B) and the semi-structured interviews (Appendix D). Non-participant laboratory observations have been used by many researchers to explore interactions between teachers' perceptions of instruction and their actual laboratory instructional practices (Wallace & Kang, 2004; Kang & Wallace, 2005). Two of the interviewed teachers; a male teacher designated as 'C' and a female teacher designated as 'E', were selected on the basis of convenience and each observed during three laboratory sessions. These teachers were close to where the researcher was staying, and were willing to be observed. Teacher C was observed for three 90 minutes class periods. Teacher E was observed for two lessons of 45 minutes each and a 90 minutes class period.

The researcher sat at the back of the classroom, so as to minimize the observer effect on the observed, but where most of the teachers' and students' activities during the lesson could be seen. Using the laboratory schedule the researcher recorded what transpired during the lessons including incidents that might be useful for the intended exploration. One disadvantage of an observation is that the presence of the observer can affect the normal behavior of those being observed (Borg & Gall, 1983). To reduce this observer effect, arrangements were made with the teachers to inform their students of the researchers' visit and to introduce the researcher when he entered the laboratory (Borg & Gall, 1983). This procedure was done in order to bring the students' curiosity to normal so that they could concentrate on their work. The observer effect on the teacher was reduced by highlighting the purpose of the observations, but with great care not to make the teachers change their normal laboratory practices, and render the observational data invalid.

After each observation a post lesson interview was conducted to establish reasons for using the teaching method and laboratory activities in the lesson, as well as constraints the teacher usually encountered when doing laboratory work.

3.7 Data Analysis

3.7.1 Teachers' Perceptions of Aims of Laboratory Work (TPALW)

As already said, the teachers were given a questionnaire in which the second section consisted of ten possible aims of laboratory work in which they [teachers] were asked to indicate the level of importance for each aim by choosing from "Not important", "Important" and "Very important". The third section of the questionnaire consisted of four major aims of laboratory work. The teachers were required to indicate whether each of the four aims was "Not important", "Important" or "Very important" by ticking (√) in the appropriate box. In analyzing the data responses on teacher perceptions of the ten aims of laboratory work, and teachers' perceptions of the four major aims of laboratory work, the two categories of "Not Important" and "Important" were collapsed into a single category of "Important". This means that there were now two categories of "Important" and "Very Important" for both sections. The reason why the categories of "Not Important" and "Important" were collapsed instead of collapsing the categories of "Important" and "Very important" is that there were too few responses under the categories of "Not Important" so much that the responses were not at all discriminatory to portray a true reflection of the teachers' perceptions of the ten aims of laboratory work and their perceptions of the major aims of laboratory work. For the following aims of laboratory work; 4, 6, 8 and 9 (See Fig. 4.1), the responses were 2, 2, 1, and 7 respectively under the column of "not important" while for the other aims of laboratory work no teachers thought the aims were not important. As for the four major aims of laboratory work, the responses under the column of "not important" for IM, PST and NOS & SI were 1, 2 and 1 respectively. No teachers thought conceptual understanding was not an important aim of laboratory work. Collapsing of columns in analyzing data is not new, science educators, such as Lynch and Ndyetabura (1983), have done it with the purpose of giving meaning to data. Frequency counts for both section B and section C were

generated, indicating the number of teachers who perceived the aims of laboratory work as either "Important" or "Very Important".

3.7.2 Teachers' Perceptions of Instruction (TPI)

Teachers' responses from TPI questionnaire were analyzed by assigning scores for each response from 1 to 5 as follows: almost never =1; seldom = 2; sometimes = 3; often = 4; and almost always = 5. This scoring was done for statements for which saying "almost always" would indicate practice of instruction which was highly inquiry oriented. The statements which were scored as described above were the following: 6, 7, 8, 11 ,13 ,14 ,15 ,16 ,17 ,18 ,19 ,20 ,21, and 23. The other statements were scored in the reverse order as follows: almost never =5; seldom = 4; sometimes = 3; often = 2; and almost always = 1. This scoring was done for statements for which saying "almost always" indicated an instructional practice which was highly non-inquiry oriented or expository. The statements which were scored this way were the following: 1, 2, 3, 4, 5, 9, 10, 12, 22, 24, and 25.

Each of the teachers' total score was computed. The lowest possible score was 25 and the highest possible score was 125. A low score was taken to mean that the teachers' instruction was expository (non-inquiry oriented) while a high score was taken to mean an instruction that was non-expository (inquiry oriented). The median score was calculated for the range of scores from 25 to 125 which is a score of 75. Teachers who scored from 25 up to 74 were classified as 'expository instructivists' while those who scored from 75 up to 125 were classified as 'inquiry oriented instructivists'. Frequencies were generated to represent the number of teachers falling under each category. These frequencies were then expressed as a percentage.

3.7.3 Teacher perceptions of aims and use of laboratory work - Open ended questionnaire

3.7.3.1 Teachers' perceptions of aims of laboratory work

The teachers' responses on perceptions of laboratory work (question 1 - Appendix C) were analyzed using typological analysis (Hatch, 2002). In this analysis, data are categorized using predetermined typologies either emerging from the data or derived from the literature. The

typologies on the aims of laboratory work, derived from the literature (Lynch & Ndyetabura, 1983; Wilkinson & Ward, 1997; Staer *et al*., 1998; Hodson, 1993; Millar, 2004) were imposed on the teachers' responses on their perceptions of the aims of laboratory work. These typologies were conceptual understanding, interest and motivation, process skills and techniques, and the nature of science and scientific inquiry. Teachers' responses were read several times to get the essence of the whole text for each response. The text was then read for the purpose of analysis, bearing one typology in mind. Statements/phrases in the text containing information related to each of the typologies were underlined and coded for the respective typologies. The following codes were assigned to the four typologies: conceptual understanding (CU); interest and motivation (IM); process skills and techniques (PST); and the nature of science (NOS) and scientific inquiry (SI). Frequency counts were generated and each typology was counted once even if it appeared more than once. The frequencies represented the number of teachers; say for example who held the view that the aim of laboratory work was to develop interest and motivation. The frequencies were then expressed as a percentage.

3.7.3.2 Teachers' use of laboratory work

Teachers' responses on perceptions of use of laboratory work (questions 4 & 5 – Appendix C) were also analyzed using typological analysis (Hatch, 2002). Unlike in the previous analysis, where typologies were derived from the literature, this time the typologies used for analysis were those emerging from the data set, regardless of whether they were similar to the typologies derived from the literature or were new typologies altogether. The text was read and reread, and statements/phrases containing meaning units relevant to use of laboratory work were underlined to identify typologies. The typologies were coded as follows: help in students understanding of theory (UT); make science interesting (MIS); nature of science and scientific inquiry (NOS); and development of process skills (PS). The text was then read with one typology in mind. Statements/phrases containing related information for each typology were assigned to the relevant category. Frequencies were then generated representing the number of teachers belonging to each category. The frequencies were expressed as percentage frequencies.

3.7.4 Teachers' perceptions and use of laboratory work- analysis of interview data

In analyzing the interview data, the typological model of analysis was used (Hatch, 2002) and interpretational analysis (Gall *et al.* 1996). As explained in the previous section, in typological analysis predetermined categories are imposed on data set. Firstly, predetermined typologies relating to the aims of laboratory work were identified from the literature (Lynch & Ndyetabura, 1983; Wilkinson & Ward, 1997; Staer *et al*., 1998; Hodson, 1993; Millar, 2004): Conceptual understanding, interest and motivation, process skills and techniques, and the nature of science and scientific inquiry. Secondly the interview data was read several times to get a sense of the whole data for each participant, and then read for analysis with only one typology in mind. Thirdly, data segments (excerpts) which were related to the typology in mind were underlined and assigned a code for the respective typology. The following codes were assigned for the typologies: conceptual understanding (CU); interest and motivation (IM); process skills and techniques (PST); and the nature of science and scientific inquiry (SI). Fourthly, brief summaries expressing the main idea of each excerpt were noted down for each participant, and these summaries were later used to identify patterns within the typologies. Finally interpretational analysis was done based on the observed patterns, and powerful excerpts from the data which were supporting the generalizations were selected for inclusion in the presentation of results. According to Hatch (2002) excerpts allow the readers to hear the voices of participants.

3.8 Conclusion

In this chapter the design of the research was given also highlighting issues of validity and reliability. The instruments used to collect data were described indicating how validity and reliability were catered for. The teachers who participated in this study and how they were sampled were described, and data collection procedures were also described. The steps followed in analyzing data were discussed. Ethical principles and how they were adhered to in this study were described. In chapter 4 the results of this study are presented and discussed.

Chapter 4

Results and Discussion

4. Introduction

This chapter presents and discusses the findings of the study. The presentation and discussion is done under the research questions, which are:

(1) What are the teachers' perceptions of the aims of laboratory work in school science?

(2) How do the teachers use laboratory work in the teaching of science?

(3) What is the relationship (if any), between teacher perceptions and use of laboratory work?

4.1 Teachers' perceptions of the aims of laboratory work in school science

Results presented here are from the closed questionnaire, the open-ended questionnaire and interviews.

4.1.1 Results from Teachers Perceptions of Aims of Laboratory Work questionnaire

Figure 4.1 in the next page shows teachers' responses to ten closed items on the Teachers Perceptions of Aims of Laboratory Work questionnaire (TPALW) (Appendix A). In responding to the items, teachers were required to indicate how important they thought the given aim of laboratory work was by choosing from: "Not Important"; "Important"; and "Very Important". In treating the responses to the TPALW the responses (percent frequency) to Not Important and Important were collapsed into one category of Important. This meant there were now two categories of "Important" and "Very Important". Figure 4.1 in the next page shows a summary of the percent frequencies of teachers saying each objective is important or very important (n = 50).

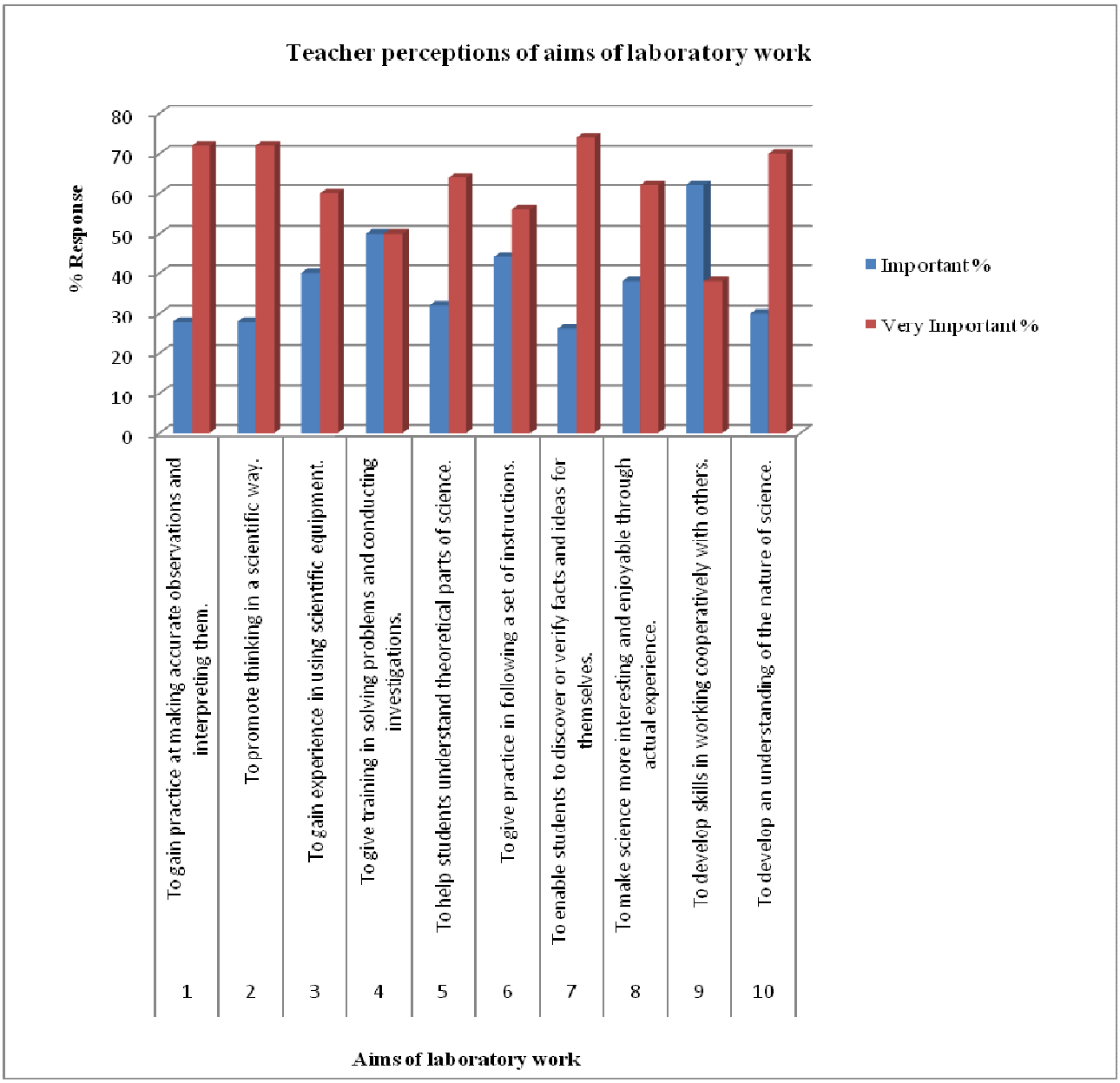


Fig. 4.1: Teachers' perceptions of the aims of laboratory work

According to the teachers, the most important aim of laboratory work is aim 7: "to enable students to discover or verify facts and ideas for themselves". Seventy four percent (74%) of the teachers were of the view that this was a very important aim of laboratory work. That such a

large number of teachers in this sample sees verification of theory as the most important goal for laboratory work is not a surprising finding. Over the years, research done elsewhere has consistently shown that many teachers believe that the most important purpose of laboratory work is to help learners understand theory by making otherwise abstract and complex phenomena simple and concrete, thus, verifying theory (Lynch & Ndyetabura, 1983; Wilkinson & Ward, 1997; Jenkins, 2000; Hodson, 2005; Ottander & Grelsson, 2006).

Most of the teachers in this sample were trained in the true colonial tradition where emphasis is placed on mastery of the subject matter. Indeed, on many of the school laboratory walls in Lesotho are to be found beautiful charts with the traditional dictums of "let me hear and forget, see and remember and do and understand". In traditional fashion therefore, it is no wonder that the sampled teachers should feel strongly about the role of laboratory work in promoting understanding in science.

While the sampled teachers thought that laboratory work was very important for verifying theory, they were also of the view that it was important for gaining practice in making accurate observations and interpreting them (aim 1 = 72 % saying it is very important); promoting thinking in a scientific way (aim 2 = 72 % saying it is very important) and developing an understanding of the nature of science (aim 10- 70% saying it is very important). It is rather surprising that the sampled teachers should perceive these three aims as more important for laboratory work compared to training in problem solving (aim 4 = 50% saying very important) and the development of cooperative skills (aim 9 = 38 % saying it is very important). This is so because the Lesotho Junior secondary school curriculum emphasizes problem solving and investigations as well as cooperative learning as important outcomes of science education. Contrary to curriculum aspirations, it could be that the sampled teachers do not consider these two aims to be that critical at the Junior Secondary school level. Studies done elsewhere have shown that chasms between curriculum intends and teacher perceptions of the purpose of instruction are not uncommon (Hofstein & Lunetta, 2004). The low ranking of "working cooperatively with others" is also not surprising as it is consistent with the findings of the research done by Wilkinson and Ward (1997), who found that teachers in their sample did not

consider cooperation with others to be an important objective of laboratory work. Although the teachers sampled in the current study view cooperation as less important, many science educators suggest that cooperative learning is very essential in science learning (see, Hofstein and Lunetta, 2004; Hofstein, 2004; Yildiz et al., 2006).

4.1.2. Teachers' perceptions of the four major aims of laboratory work

According to Millar (2004), the aims of laboratory work can be grouped into four major categories, which are the developments of: conceptual understanding; student interest and motivation; science process skills and techniques; and understanding of the nature of science and scientific inquiry. When the teachers were asked to indicate what they thought about the importance of the four major aims of laboratory work according to: "Not Important"; "Important"; and "Very Important", the results produced were as shown in Figure 4.2 below. As was the case with the ten aims, in treating the responses, responses (percent frequency) to "Not Important" and "Important" were collapsed into one category of "Important". This meant there were now two categories of "Important" and "Very Important". Figure 4.2 in the next page shows responses on teacher perceptions of major aims of laboratory work categorized under conceptual understanding, interest and motivation, process skills and techniques, and the nature of science and scientific inquiry.

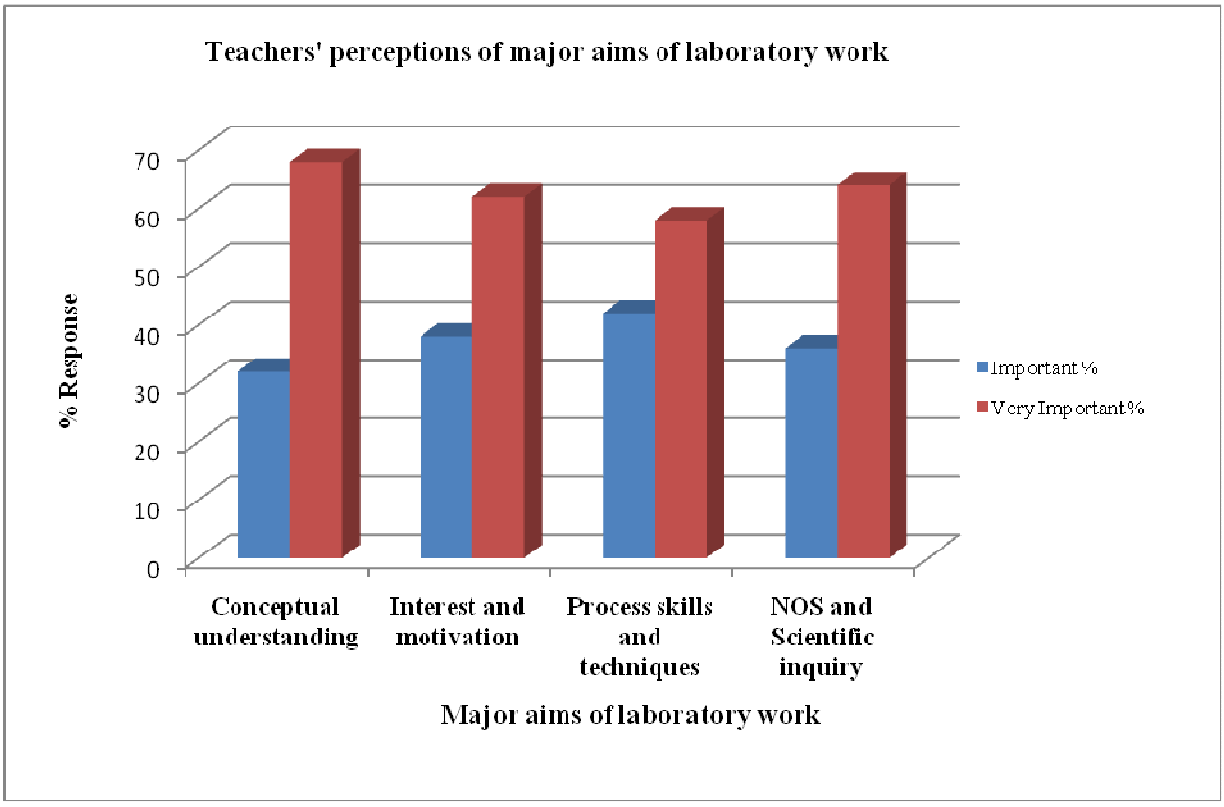


Fig. 4.2: Teachers' perceptions of the four major aims of laboratory work

As was the case with the list of ten aims, the data in *Figure 4.2* above appears to give credence to the fact that the majority of the sampled teachers believe that the most important aim of laboratory work is to develop conceptual understanding. This is in line with findings from studies done elsewhere (see, Hodson, 2005; Pekmez et al., 2005). Perhaps this could be explained in terms of teachers' beliefs about the nature of science and successful learning of science. In her study, Cronin-Jones (1991) found that teachers' beliefs, that students' learning in science involves the acquisition of factual knowledge, were linked to their ideas about science. As Hashweh (1996) found out, teachers who held empiricists ideas about science were also found to harbour the belief that science is an objective body of knowledge that could be taught using reinforcement laboratory instructional strategies that emphasize the 'scientific method'. On the other hand the constructivists believed that students constructed their own knowledge, hence they employed different instructional strategies. It would be interesting to find out the ideas about science and scientific inquiry held by Lesotho Junior Secondary school teachers and to see

whether there is any relationship between their ideas about science and their perceptions of laboratory work.

The least important aim of laboratory work, according to these teachers, is to 'develop laboratory skills and techniques'. This may suggest that teachers do not give students an opportunity to engage in experiments through manipulation of materials and equipment, so that the aim of developing skills is realized.

4.1.3 Teachers' perceptions of laboratory work for conceptual understanding and gender

It was interesting to find out whether teacher perceptions of laboratory work as important for conceptual understanding was associated with gender. Many variables in education have been found to be gender associated (Catsambis, 1994). To test this association a Chi-Square test was performed, with significance set at p = 0.05. A 2 X 2 contingency table was set for one degree of freedom as shown in Table 4.1 below.

Table 4.1: Contingency table for observed (O) and expected (E) frequencies

		Gender				
		Male		Female		
		O	E	O	E	Total
Perception of laboratory work	Important	23	17	11	17	34
	Not Important	10	8	6	8	16
	Total	33	25	17	25	50

$$\chi^2 = \frac{\sum (O-E)^2}{E}$$
$$= \frac{(23-17)^2}{17} + \frac{(11-17)^2}{17} + \frac{(10-8)^2}{8} + \frac{(6-8)^2}{8}$$
$$= 5.24 \ (1 d.f)$$

From the probability table, the value of χ^2 (1) for the level of significance of 0.05 with one degree of freedom is 3.84, which indicates that the rating of conceptual understanding as an aim of laboratory work is associated with gender. Although it would be interesting to find out whether the three other major aims of laboratory work were associated with gender, their association was not tested, as it was felt enough to concentrate only on what the teachers said was most important. This issue can be pursued outside the framework of this Masters thesis.

4.1.4 Results from open ended questionnaire and interviews

The results presented here are from the open ended questionnaire and from the interviews. In analyzing responses from open-ended questionnaire (Appendix C), each of teacher's responses to all the open ended items in the questionnaire were read and re-read. It was then decided whether any of the statements or phrases written by the teacher represented commitment to each of the four major aims of laboratory work namely: conceptual understanding; student interest and motivation; science process skills including laboratory skills; and understanding of the nature of science and scientific inquiry. Statements and/or phrases written by the teacher were underlined and coded according to whether they belonged to the four major categories/ aims of laboratory work. Each statement/phrase belonging to a category was counted only once, even if the teacher repeated the phrase in answering different questions or in different parts to answering the same question. The total number of teachers expressing statements/phrases falling into each of the four categories was counted and expressed as a percentage frequency. The results are summarized in Table 4.2 in the next page. The frequencies indicate the number of teachers expressing the idea. It should be noted that the total frequency for all the categories exceeds 100%. This is because one teacher could express ideas falling into all the categories. For each category (major aim of laboratory work), representative statements expressing commitment to a category are shown (Table 4.2). The exemplary statements have been captured directly from the interviewed teachers' responses in order to give a feel of the teachers' perceptions of the aims of laboratory work.

Table 4.2: Questionnaire results-Teachers' perceptions of the aims of laboratory work (n=50)

Major aim of laboratory work	Examples of exemplary statements	Number of teachers expressing idea	% frequency of teachers expressing idea
Conceptual understanding	Students understand clearly the facts taught in classroom. Better understanding. Verify concepts.	40	80
Interest and motivation	It makes science interesting. To have interest in learning science.	1	2
Process skills and techniques	Enables students to develop manipulative skills. To promote students' thinking ability. Helps students develop handling skills.	10	20
NOS and scientific inquiry	Encourages development of scientific strategies for solving problems and logical thinking. To investigate. Promotes students' ways of solving scientific problems.	7	14

The results in Table 4.2 above indicate that eighty percent (80%) of the teachers share the same view that conceptual understanding is the most important aim of laboratory work. This is

consistent with findings from the closed questionnaire. As is the case with closed questionnaire, the teachers' perceptions are consistent with findings from previous studies (see for example, Hodson, 1990, Wilkinson & Ward, 1997). A surprising finding from the open-ended questionnaire is that only one (2%) of the sampled teachers said laboratory work is important for developing interest and motivation. This is so when it is considered that in responding to the list of ten aims, sixty two percent (62%) of the teachers had said this objective was very important (see Figure 4.1). In responding to this part of the questionnaire, only one teacher indicated that laboratory work is useful for stimulating students' interest in learning science. This could raise issues about the validity and reliability of item 8 of the closed questionnaire. It might be that teachers really never think about promoting interest and motivation as an important aim of laboratory work unless asked to do so by a questionnaire!

As table 4.2 shows developing process skills and techniques (20 %) and promotion of understanding of the NOS and scientific inquiry (14%) were also less popular among the sampled teachers. It would appear that to the sampled teachers, the most important aim of laboratory work is to promote conceptual understanding. This is especially so when their responses to the closed questionnaire is also taken into mind.

The teachers' belief that laboratory work is there to enhance understanding of theory is also evident from the interviews. In the interview, one of the interviewed teachers said:

> Like I have already indicated that the aim of laboratory work is to prove or to confirm the theories we read about in the textbooks. Then secondly, I have already mentioned that laboratory work makes those concepts to be clearly understood by the kids; better understood by the kids.

Four of the interviewed teachers expressed this view. This is in line with such statements from the open-ended questionnaire as: "students understand clearly the facts taught in classroom"; "better understanding" and science is for "verifying concepts".

While the majority of the teachers viewed developing an understanding of theory as the most important aim of laboratory work, they also thought that development manipulative skills and process skills were important (20 %) mentioned this in responses to open-ended questions). Two of the teachers designated here as TC and TE, expressed themselves as follows:

TC…When you are conducting an experiment, for example, on density, the students find mass using a beam balance, and also convert units of measurement. This develops their skills

TE…Like I have just hinted that the laboratory is a place where students experience a lot of things. They can use instruments, they can manipulate objects and they are engaged a lot because they are the ones who do the work. So I think every school should have a laboratory in order to help students because in the teaching students should be more engaged than the teacher… I am against that since really when the students observe things and take part in the activities….

Three of the interviewed teachers also talked about the role of the laboratory in motivating students. According to them, when students engage in experiments they tend to enjoy them [experiments] and develop interest in science. This is how one of the teachers responded to a question on the importance of laboratory work:

…It is to help students to observe what they do in class in a practical situation. Even interest in science is developed. They develop a liking in science, that is, they want to know more. They may also want to advance their knowledge of science…

In the interview, one of the teachers also alluded to laboratory work as a means for developing scientific inquiry:

I think students learn what science is because science is about what you see and how you deal with things. So when students are in the laboratory, really there is much knowledge they get themselves by using their senses…

Overall it appears that the perceptions of the purpose of laboratory work revealed by the teachers from open-ended questions and interviews are consistent with the aims of laboratory work found in the literature (Garnett et al. 1995; Hodson, 2005). The sampled teachers' views are that the aims of laboratory work are to: promote conceptual understanding, develop interest and motivation in students, develop process skills and techniques, and enhance the understanding of the nature of science and scientific inquiry. This is consistent with the views of other science educators from around the world (Millar, 2004). However, according to the teacher questionnaire and interview transcripts, the most important aim of laboratory work is to promote conceptual understanding. Similar results have been found in previous studies (Pekmez et al. 2005; Ottander and Grelsson, 2006). Although the development of cooperative skills is

considered as an important aim of laboratory work (e.g. Hofstein, 2004), teachers in this study did not view it as that important.

4.2 Teachers' use of laboratory work in teaching of science

The results presented here are from the closed questionnaire, the interviews, and laboratory classroom observations.

4.2.1 Results from the Teachers' Perceptions of Instruction Questionnaire

In analyzing the teachers' responses from the Teachers' Perceptions of Instruction (TPI) questionnaire (see, Appendix B), each teacher's response to an item on the questionnaire was given a score from 1 to 5, in the following manner: almost never = 1; seldom =2; sometimes = 3; often = 4; and almost always = 5. This scoring was done for statements for which saying almost always would indicate practice of instruction which was highly inquiry oriented. For example, if the teacher's response (√) to item 21 "Students identify problems to investigate" was almost always, a score of 5 was given. This was taken to mean that the teacher's practice was highly inquiry oriented since in inquiry oriented instruction it is encouraged that teachers allow students to identify the problem for investigation. For some statements however, the scoring described here was done in reverse. These statements were 1, 2, 3, 4, 5, 9, 10, 12, 22, 24, and 25. For these statements, scoring was done in the reverse because saying almost always meant practicing instruction which was lowly inquiry oriented or expository. An example of such items is item 24: "Students usually know what is expected of an experiment before doing the experiment". Saying almost always to this statement means practice of expository verificationistic oriented instruction. Almost always was therefore scored as = 1, with almost never getting a score of 5.

Each of the teacher's total score for the 25 items was computed. A high score (maximum = 125) is taken to mean a laboratory instruction which is highly inquiry oriented, while a small score (minimum = 25) is taken to mean that the laboratory instruction is expository. The median score of 75 for the range 25 to 125 was used to dichotomize the sampled teachers' perceptions of their practices in instruction as non-expository (inquiry-oriented) and expository (non-inquiry oriented). Teachers who scored between 25 and 74 were classified as "expository instructionists", and those who scored 75 up to 125 as "inquiry oriented instructionists". The

frequencies of teachers falling into each category were computed. Table 4.3 and Figure 4.3 below show a summary of the results.

Table 4.3: Closed questionnaire results-Teachers' use of laboratory work

Instructional style	Score range	Frequency	% Frequency
Expository Instruction	25 - 74	34	68
Non-expository Instruction	75 - 125	16	32

The information in Table 4.3 above has been shown diagrammatically in figure 4.3 below.

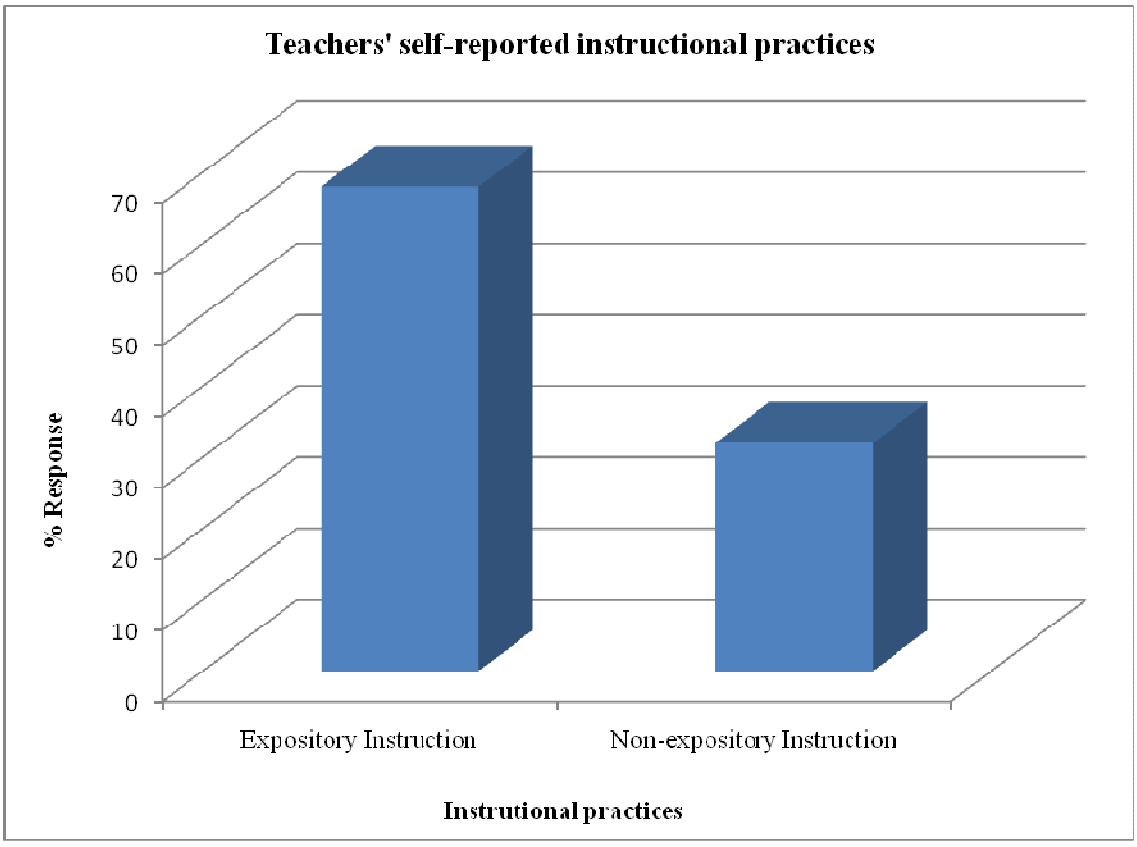


Fig. 4.3 Teachers' self-reported instructional practices

From the results in Table 4.3 and Figure 4.3 in the previous page, the majority of sampled teachers said their instructional practice was expository or non-inquiry oriented. Sixty eight percent (68%) of the teachers indicated that they use expository (non-inquiry) instruction compared to thirty two percent (32%) who indicated that their instruction was inquiry-oriented. These results are consistent with the findings by Staer et al. (1998) whose study in Australia found that 84% of the teachers in the sample for their study practiced expository instruction compared to 16% who practiced inquiry-oriented laboratory activities. These teachers' expository practices may be attributed to their enculturation into the learning of science. The sampled teachers may have been taught in an expository way and therefore hold the belief that this traditional instruction is best for students' understanding of science (Woolnough & Allsop, 1985). Expository instruction is a common practice in most science classes around the world (Roth, 1994; Tsai, 2002; Hofstein & Lunetta, 2004).

It is also that instructional barriers may hamper the use of inquiry oriented strategies in school science laboratories in Lesotho. Barriers to the use of inquiry-based laboratory work activities are well documented in the literature (Keys & Bryan, 2001; Wallace & Kang, 2004; Cheung, 2007). These barriers include limitations of resources; time constraints; large classes; teacher efficacy; teachers' epistemological beliefs; pressure to complete the prescribed curriculum; safety issues; and preparations for external examinations (Staer et al. 1998; Hofstein & Lunetta, 2004; Wallace & Kang, 2004; Hodson, 2005; Cheung, 2007). Previous studies have shown that teachers holding naïve epistemological beliefs tend to use verificationist laboratories (Hashweh, 1996; Wallace & Kang, 2004; Kang & Wallace, 2005). Science educators have also established that teachers with traditional views of science teaching and learning resist change from the closed inquiry to the open inquiry approaches because they have experienced successes in the traditional forms of instruction, such that they perceive no potential benefits in the advocated constructivist teaching approaches (Trumbull & Slack, 1991). It is highly likely that teachers in this study hold beliefs that are similar to those held by teachers in the studies done above, and experience similar teaching conditions that might possibly influence their laboratory instructional styles. This could be an area for further investigation.

4.2.2 Results from open ended questionnaire

The sampled teachers' responses to the open ended questionnaire (Appendix C) pertaining to their use of laboratory work were similar to the responses obtained on their perceptions of the importance of laboratory work. However, from the analysis, some main ideas expressed by the sampled teachers emerging from their responses are shown in Table 4.4 below.

Table 4.4 Main ideas emerging from teachers' responses

Main ideas expressed by teachers	Examples of teacher statements	% frequency of teachers expressing idea
Help in students understanding of theory	Help clear some misconceptions about some science concepts Link theory to practical work Coordinating theory with evidence What we see is better and easier to understand than what we hear	66
Make science interesting	They bring students' curiosity as they like to have their own innovation Develops interest and positive attitude	5
NOS and scientific inquiry	Learn what science is all about Know about the scientific method	19
Development of process skills	To equip students with skills and techniques Promotes students' of solving scientific problems.	18

The fact that the sampled teachers have given responses similar to those given in the previous part of the open-ended questionnaire, could point towards a poor validity for the questions asked in the open-ended questionnaire. Perhaps the terms used in the questionnaire have not provided a clear distinction between aim and use of laboratory work. As the Table shows, the majority of the sampled teachers said they used laboratory work to teach theory. However, some teachers

said they used the laboratory to teach about what science is and to promote student interest. Of interest is the fact that many of the teachers who said they used laboratory work to teach theory expressed the idea that laboratory work could be used to challenge students' misconceptions. This is in line with Al-Naqbi and Tairab (2005) who report several studies as having shown that many science educators believe that laboratory work is very useful for confronting students' misconceptions and facilitating conceptual change.

4.2.3 Results from interviews

All the five teachers stated that they do laboratory work at least once a week. According to these teachers the number of laboratory activities done per week basically depended on whether the topic being taught requires much use of the laboratory or not. The five teachers also stated that they do not give students the opportunity to design and conduct their own experiments. This gives validity of the findings from Teachers' Perceptions of Instruction Questionnaire, in which most of the teachers said their practice was expository. However, all the five teachers appreciated that giving students opportunities to design and conduct their own experiments could increase students' potential in doing science. Some of them mentioned that this should only be done provided the experiments which students are allowed to design and conduct were not dangerous! One of them, designated as TA, said:

> **TA:** Yah! I think it is important as long as they are using materials that are not dangerous.

One of the teachers expressed the idea that teaching was primarily aimed at using laboratory work to teach for understanding so that learners would pass the examination. He said:

> Really this is a good thing but we are working under pressure to cover the syllabus, and we want the students to understand based on how we want the examination results to look like at the end of the year. It is a good thing but …

During the interviews, two of the interviewed teachers were given two critical incidents to respond to. In their responses they both indicated that when unexpected experimental results are obtained, students should be offered another opportunity to repeat the experiment in case they might have gone wrong somewhere. This indicates that these teachers hold the belief that

laboratory activities are used for verification purposes (Kang & Wallace, 2005). This is how one of them responded:

> Simply speaking, the groups with unexpected results should be given another chance to do the experiment in order to check their accuracy…

It appears that this teacher confuses accuracy of results with repetition of tests or procedures.

Concerning classroom organization all the teachers explained that students work in groups mainly due to lack of resources. According to them, students are given worksheets outlining the procedure and the teachers act as learning facilitators by providing guidance where necessary. This is a typical example of non inquiry instruction (Domin, 1999). The teachers also added that at times they are forced to use teacher demonstration. Two of the teachers stressed that teacher demonstrations are also preferred due to students' low ability and for safety reasons. It was also mentioned that due to time constraints, pressure to finish the prescribed syllabus or curriculum, and preparations for examinations, most of laboratory work has been reduced to classroom instruction. Responding to the question of problems normally encountered in doing laboratory work, Teacher E said:

> Yes, time is another problem. Earlier on you asked me how frequently I used the laboratory. Even the time that is allocated for laboratory work, the double period, is not enough to finish the laboratory activities. So in most cases we do the work in the classroom because there is not enough time in the laboratory…

This statement might mean inadequacy in teacher pedagogical content knowledge (PCK) for laboratory work teaching. Teachers might not have enough expertise to be able to judge how much time an activity will take, and which activities to select. Teacher PCK is known to influence both planning and implementation of teaching strategies (Shulman, 1986).

According to the interviewed teachers, no assessment is made on students' performance during laboratory work. However three of the teachers indicated that they sometimes mark worksheets during or after the laboratory activities or at other times, students write laboratory reports which

are marked after laboratory experiments/activities. This is how two of these teachers responded to the issue of assessment, designated here as TC and TE:

> **TC…**After the experiment the students write a report which is composed of the following: Apparatus, procedure, observation, results and conclusion. Then I mark the report making comments to show where improvement is necessary

> **TE…**It depends on the topic that is treated. In most cases I give worksheets which I collect after the experiment for marking. Sometimes I mark the worksheets during the activity as I move from one group to another

The interview results above show that the general organization of laboratory work in their schools is that students work in small groups, or demonstrations mainly due to limited resources which do not allow individual activities. Although no other reason was given for implementing group work, some science educators have argued that group work increases students' participation in laboratory work activities and helps students to confront their misconceptions by challenging each other's perspectives of science (Herrenkohl and Guerra, 1998). According to these teachers, the regularity of laboratory work is determined by the nature of the topics they are teaching. All the interviewed teachers said they did experiments at least once a week.

The teachers also indicated that the time allocated for laboratory work is not sufficient for the students to finish their laboratory work activities; as a result laboratory work is supplemented by classroom theory. Impediments to effective laboratory practices that are associated with management in schools have been reported elsewhere (Al-Naqbi & Tairab, 2005). In this study teachers have complained that school heads often do not see the importance of laboratory work in the school, hence no financial provision is made to make laboratory resources available. This problem of lack of resources in the laboratories in Lesotho seems to be a major problem impeding inquiry oriented laboratory instructional practices. Hofstein and Lunetta (2004) have argued that laboratory activities should provide students with opportunities to develop problem solving and investigative skills.

The teacher interviews suggest that the sampled teachers do not provide such opportunities. The results also show that the sampled teachers do not assess laboratory work effectively.

4.2.4 Results from laboratory class observations

The findings are reported and discussed here for each of the two observed teachers. The teachers are designated Teacher C and Teacher E.

Teacher C

Teacher C was a young competent man who held a Bachelor of Science with Education degree at the time of this study. He had specialized in Mathematics and Physics from the National University of Lesotho. He taught at both the junior and senior secondary school levels. Although C had only been in this school for one and half years, he was already planning to leave the teaching profession and venture into engineering.

For Teacher C, all the observed lessons, activities were based on photocopies from students' textbooks. For each of the activities clear lists of apparatus, diagrammatic set up of the activity, procedure, and the expected outcome were given; in typical expository and verification approach. The observed pattern for C in conducting laboratory work activities was that he would introduce his lessons by either asking knowledge level questions or re-defining concepts taught in the previous lesson. For example, in introducing one of his lessons he said: "We said that when solids are heated they…". The students would then answer in a chorus saying: "They expand". Teacher C would then affirm saying: "Yes they expand, what about when they are cooled?". It looked like the teacher was affirming his conviction of the aim of laboratory work as enhancing students' understanding of theory. Indeed following the introduction the laboratory work activities that followed were used to confirm scientific concepts already taught. This appeared to be the pattern in all three observed lessons. To achieve his convicted aim the teacher seemed to always make laboratory work follow his classroom teaching so that concepts already taught could be verified. Typically, he started the activity by stating its purpose. He would then explain the procedure in the given worksheet or written on the board. Teacher C was seen to use group work during which he moved from one group to another providing guidance where

necessary. These groups as observed did not show high levels of student-student and student-teacher interaction, possibly because they were on activities involving concepts which were already taught, as a result did not bring any challenge to students. In one of the activities on finding the centre of gravity of an irregular plane lamina, students worked in large groups due to limited equipment and more often the students went off task and chatted. In the third observed lesson, an activity on investigating factors affecting the period of a pendulum was done. The students were given the variables that should be investigated; length of string, size of bob and angle size. The teacher went round to help students who had problems. In this particular lesson, the students demonstrated a high level of interaction with the teacher and amongst themselves. Possibly this might have been due to the fact that the activity was involving in nature, for example, measuring, time keeping, counting, and recording of data such that there was a clear division of labor amongst group members. However, for all the observed lessons no post laboratory exercises were given.

Teacher E

Teacher E had been in her school, which is a community school, for 21 years. She held a Secondary Teachers' Certificate from the National Teacher Training College, now called the Lesotho College of Education. Her subjects of specialization were Mathematics and Science. She taught at the junior secondary school level. She complained that most of her laboratory activities are demonstrations because of lack of equipment.

Teacher E also followed a pattern similar to C's in which she introduced her lessons by asking students questions on what had previously been covered in the classroom, before stating the purpose of the activity. She used student and teacher demonstrations. She later indicated that most of her laboratory activities are demonstrations and in some cases some topics are only treated theoretically in the classroom. Where resources are available, Teacher E used group activity, but it took the same form as for Teacher C.

During two of the observed lessons she appeared to be directing students' observations although she did not ask the students to explain their observations. The act of directing students' observations makes the lesson teacher-centered, which is against the principles of a constructivist

teaching approach, of learner-centeredness. In one activity on finding the volume of a stone, she interrupted: “Is this how we measure the volume of water?” A demonstrating student was holding the measuring cylinder up in one hand and trying to take a reading. She was seen to involve the students in the demonstrations through questioning or asking them to provide assistance in particular instances. Students either listened to her explanations, or answered her questions apart from making observations. According to Domin (1999) expository laboratory activities allow students to use the lower cognitive abilities of Bloom’s taxonomy of educational objectives; knowledge, comprehension and application. It looks like this is what was happening in Teacher E’s classes. Students were not presented with challenging situations that provoke their thinking. However, during group work E was seen to move around giving guidance to students when appropriate. Like Teacher C, she also did not give any post laboratory exercises.

4.2.5 Teacher use of laboratory work: some pertinent comments

The laboratory instructional styles employed by these teachers may be attributed to three main factors. Firstly, the availability of resources in the laboratories, allocations of laboratory work in the school timetable, and large classes. According to Swain et al. (1999) the selection of instructional practices is determined by the teaching conditions under which teachers find themselves. This suggests that teachers working in under-resourced laboratories are highly likely to use closed inquiry approaches. These results match the findings of previous studies (Wilkinson & Ward, 1997; Cheung, 2007). Secondly, teacher beliefs play an important role in determining teacher decision-making (Vhurumuku, 2004). Many studies have found that teachers holding naïve epistemological beliefs tend to use expository or highly structured laboratory activities (Hashweh, 1996; Tsai, 2002; Kang & Wallace, 2005). Thirdly, teachers may not be well informed about the recommended professional practices (Hofstein & Lunetta, 2004). According to these authors, there is a high potential for mismatch between what is expected and what actually transpires in the laboratory. This suggests that teacher professional development is a requisite for updating teachers on science curriculum reform.

The assessment of school science laboratory work seems to be a forgotten aspect altogether (Hofstein & Lunetta, 2004). None of the interviewed teachers gave an efficient method for

assessing laboratory work. Neither did the observed teachers do any assessment during their lessons. However, during the interviews some of the teachers said they did some marking of worksheets during or after laboratory work while others indicated that students write laboratory reports after working on experiments. The truth of the matter appears to be that teachers are not doing enough to assess students' acquisition of science process skills. It is not surprising that these teachers do not take laboratory work assessment seriously. The Ministry of Education of Lesotho through its assessment of practical work using only a paper-and-pencil examination (Ministry of Education and Training, 2006) appears to be encouraging teacher malpractices. The assessment of laboratory work skills through practical examinations has been recommended by several authors (see, Hodson, 1992; Hofstein & Lunetta, 2004). One other reason why teachers might not assess laboratory work skills could be that they have not been exposed to the variety of ways through which assessment might be done. This being the case, it is important to note that direct observation of students' performance has been criticized as being too time-consuming (Gott & Duggan, 2002; Roberts & Gott, 2004). For this reason, the assessment of written reports is in fashion in many parts of the world. Hofstein (2004) has suggested that assessment of laboratory reports, direct observation, and practical examinations, formative and summative assessments could all be combined in the assessment of laboratory work.

4.3 Relationship between teacher perceptions and use of laboratory work

In this section results are presented and discussed for the third research question. First association was tested for between teacher perceptions of the importance of laboratory work aims and teacher use of expository or inquiry oriented instruction. To test this association a Chi-Square (χ^2) test of association with Yates's correction for continuity was performed. Second results from observation of teachers' classes and interviews are considered.

4.3.1 Chi-Square test of association between teacher perceptions of laboratory work for conceptual understanding and their use of inquiry-oriented strategies

Table 4.5 below shows a contingency Table for the Chi-Square (χ^2) test of association with Yates's correction for continuity in which teacher perceptions of results were used to explore the possibility of any relationship that might exist between teachers' perceptions of the aims of

laboratory work and their use or non use of expository or inquiry oriented instruction. The cross tabulation was between teacher perceptions of promotion of conceptual understanding as a laboratory work aim versus their use of expository or inquiry oriented strategies.

Table 4.5: Contingency table for observed (O) and expected (E) frequencies

	Use of laboratory work				
Perception of laboratory work aim (Conceptual understanding)		**Expository**		**Non-expository**	
		O	**E**	**O**	**E**	**Total**
	Very Important	29	22.5	16	22.5	45
	Important	4	2.5	1	2.5	5
	Total	33	25	17	25	50

$$\chi^2 yates = \sum_{i=1}^{N} \frac{\left(|O_i - E_i| - 0.5\right)^2}{E_i}$$

$$= 1.6 + 1.6 + 0.4 + 0.9$$

$$= 4.00 \ (1 d.f)$$

From the probability table, the value of χ^2 (1) for the level of significance of 0.05 with one degree of freedom is 3.84, which indicates that the teachers' perception that the aim of laboratory work is to promote conceptual understanding is associated with their use of laboratory work. It needs be noted that the association here is actually between teacher perceptions of the aims of laboratory work and what teachers reported they were doing in terms of their practices. All the same, teacher perceptions of their practices have been used as reliable indicators of their actual classroom practices (see, Tobin and Fraser, 1998). From this it could safely be said that there is some link between perceptions of promotion of conceptual understanding as a laboratory work aim and their use of expository or inquiry oriented strategies.

4.3.2 Results from interviews and lesson observations

During the interview, Teacher C indicated that the aim of laboratory work is to promote conceptual understanding. To achieve this aim, this teacher was observed to follow a particular pattern in which he introduced concepts in the classroom and later engaged students in laboratory work to illustrate or elucidate the theory acquired in the classroom. It could be suggested that Teacher C's perception of the aim of laboratory work is influencing his practice or use of laboratory work. For Teacher E the most important aim of laboratory work is to help students discover things for themselves, and also to help them grasp science concepts. In conducting laboratory activities she was seen to use a demonstration, in which she directed students' observations without necessarily asking the students to explain those observations. She also used student demonstrations, a style of instruction which science educators classify as expository (Vhurumuku, 2004). Students' involvement in both demonstrations was of a low cognitive level (Kang & Wallace, 2005), which is characteristic of expository instruction (Domin, 1999). It is apparent from the explanations on Teacher E's lesson observations given above, that Teacher E's perceptions of the aims of laboratory work appear to contradict her laboratory instructional practices.

While this might be so, in both the questionnaire and the interview Teacher C's responses point towards his practices being expository (non inquiry oriented), whereas Teacher E's responses seem to be expository in the questionnaire and inquiry oriented in the interview. It could also be that the teachers' choices of practices in instruction are influenced by factors other than their perceptions of the aims of laboratory work. As Teacher E revealed during the interview, such variables as time allocated for laboratory work might determine the nature of the practice. Teacher E said:

> Yes… time is another problem. Earlier on you asked me how frequently I used the laboratory. Even the time that is allocated for laboratory work, the double period, is not enough to finish the laboratory activities. So in most cases we do the work in the classroom because there is not enough time in the laboratory.

Teacher E further isolated the availability of resources as a constraint, which might also have a bearing on her instructional practices. She moaned:

> The problems I encounter include lack of materials in which case I have to demonstrate.

Teacher beliefs about the nature of science have also been known to influence teacher practices (Al-Naqbi & Tairab, 2005). From their interview responses all the interviewed teachers appear to harbour the notion that science is a body of knowledge that can be transmitted onto learners through direct teaching using laboratory work to verify concepts. This is evidenced by the following extract from interviewing one of the teachers:

> There is this saying that 'we see we understand'. Therefore by seeing and manipulating scientific apparatus, it becomes easy for the students to understand what they learn and also to remember what they have learned easily. But if you tell them, without giving them the opportunity to manipulate objects, the next day or the next week when you ask them what they had learned they would have forgotten almost everything. But if they are given a chance to touch some of the laboratory apparatus or materials they will remember very easily.

While teacher practices and use of laboratory work appear to be influenced by their perceptions of laboratory work aims, the uses and practices also appear to be influenced by a variety of other factors including availability of resources, time constraints and teacher perceptions of the nature of science. This is not a surprising finding since all these variables have been known to influence teacher instructional practices (Kang & Wallace, 2005). Extricating the nature of relationship between teacher perceptions looks like a complex process. Further research is necessary to shed more light on this issue.

4.4 Conclusion

The analysis and discussion of results done in this Chapter shows that generally, while the sampled teachers think that laboratory work is important for teaching about the nature of science, development of science process skills and promoting student interest and motivation, their opinion appears to be that the most important aim of laboratory work is to develop a theoretical

understanding of the subject matter. Results from the closed questionnaire (TPI) have shown that a large proportion of the sampled teachers (68%) use non-inquiry oriented laboratory instruction while only 32% use inquiry oriented instruction. Laboratory observations confirmed that teachers in this study use expository (non-inquiry oriented) instruction. The Chi-square test and results from observations suggest a link between the teachers' perception of the major aim of laboratory work and their instructional practice. In the next Chapter the conclusions from the study, implications and recommendations are discussed.

Chapter 5

Conclusions, Implications and Recommendations

5. Introduction

The purpose of this study was to investigate Lesotho junior secondary science teachers' attitudes and use of laboratory work. The study particularly focused on teachers' perceptions of the aims of laboratory work, use of laboratory work, and exploring whether there was a relationship between the teachers' perceptions and their instructional practices. From the results and discussion presented in Chapter 4, three main conclusions emerged from this study:

1. The teachers believe that the most important aim of laboratory work is to make students understand theory.

2. The teachers use verificationist laboratory activities and non-inquiry laboratory instructional practices.

3. The teachers' perceptions of the aims of laboratory work are connected to their laboratory instructional practices.

These conclusions are elaborated separately in the next sections.

5.1 Teacher perceptions of the aims of laboratory work

The analysis and discussion of the results of the closed questionnaire (TPALW) (Appendix A), which elicited teachers' perceptions of the aims of laboratory work showed that the sampled teachers believed that laboratory work was important for developing students' understanding of theory, developing students' interest and motivation, developing scientific process skills and techniques, and developing an understanding of the nature of science and scientific inquiry. This finding is consistent with the views of science educators (see Hodson, 1993) and results from

previous studies (Pekmez et al. 2005; Ottander and Grelsson, 2006).) The teachers thought that the most important aim of laboratory work was to make students understand theory. This conclusion is corroborated by findings from the open ended questionnaire and interviews. The teachers' responses from the open ended questionnaire showed that 80% of the teachers were of the opinion that laboratory work enhances understanding of theory. What was surprising was that there were extremely few responses for the development of interest and motivation (2%), process skills and techniques (20%) and developing an understanding of the nature of science and scientific inquiry (14%) as compared to responses from the closed questionnaire, pertaining to the same aims of laboratory work. This was a clear indication that the teachers did not consider the other three aims of laboratory work to be that important. The responses obtained from the five interviewed teachers confirmed the results from the closed and open ended questionnaires; these teachers also indicated that laboratory work helps students understand concepts taught in the classroom that might have been too abstract or difficult for them to understand. It was interesting to find that one of the interviewed teachers stated that laboratory work was also important for making students develop inquiry learning.

5. 2 Teachers' use of laboratory work and practices in teaching science

A closed questionnaire (TPI) (Appendix B) was used to provide information on how the sampled teachers used laboratory work in teaching science. Results from this questionnaire showed that the majority of the sampled teachers (68%) used expository laboratory instructional practices. This was consistent with science educators' view that many schools continue to offer cookbook laboratory activities to students (Roth, 1994; Tsai, 2002; Hofstein & Lunetta, 2004). Only a small proportion (32%) of the sampled teachers used inquiry oriented laboratory instruction. Analysis and discussion of results from the interviews (Appendix D) showed that the sampled teachers organized group work activities at least once a week, used laboratory work for verification purposes, in which students were not exposed to inquiry oriented laboratory activities such as allowing students to design and conduct their own experiments. The study also found that the sampled teachers did not assess students' laboratory skills. Some of the teachers who made efforts to assess laboratory work did so through laboratory reports. Laboratory classroom observations (Appendix E) showed that the sampled teachers organize students into

groups to do laboratory work activities and use non-inquiry oriented laboratory instructional practices. The observations conducted, showed that laboratory work was used to verify scientific facts and principles, and that no assessment was done. The general conclusion is that the teachers offer students verificationist laboratory activities and use non-inquiry oriented laboratory instructional practices.

5.3 Relationship between teacher perceptions and use of laboratory work

A Chi-Square (χ^2) test of association was performed to explore whether there was any relationship between the sampled teachers' perception of the promotion of conceptual understanding as an aim of laboratory work, and their instructional practices. The study found that there was a link between the teachers' perceptions and their instructional practices. Interview results and classroom observations also demonstrated that there was a link between teachers' perceptions of the aims of laboratory work and their instructional practices. Teachers who believed that laboratory work was important for making students understand theory were found to be using verificationist laboratory activities. This link is influenced by scientific epistemological beliefs (Kang & Wallace, 2005) and external factors such as teaching contexts; teachers working in laboratories with limited resources or large classes may not exhibit this link. The general conclusion is that some of the teachers' perceptions of the aims of laboratory work, such as "the aim of laboratory work to promote conceptual understanding", are linked to their instructional practices. Other perceptions of the aims of laboratory work are not clearly connected to the teachers' laboratory instructional practices.

5.4 Implications and recommendations for teaching

The results of this study suggest that teaching of science in Lesotho is inconsistent with the recommended standard by science curriculum reform. This means that science education should be evaluated to find out if science teachers are aware of the advocated professional standards of scientific inquiry. The teachers use expository laboratory instruction, instead of open inquiry laboratory instruction. Expository laboratory instruction deprives students of the opportunity to develop essential scientific skills in solving authentic science-related problems. It is recommended that teachers should design investigative and problem solving laboratory

activities. Professional development programs have been recommended by science educators for inexperienced teachers (Hofstein & Lunetta, 2004; Hodson, 2005). Hodson (2005) argued that the laboratory work that pre-service teachers engage in during training does not equip them with the necessary expertise for designing inquiry oriented laboratory activities. According to Hodson (2005) professional development is necessary to provide such expertise.

5.5 Recommendations for policy makers and curriculum developers

The results of this study mean that the Lesotho science curriculum needs to be reviewed. The study has shown that teachers use non-inquiry oriented laboratory instructional practices. This suggests that the curriculum should be structured in such a way that it includes inquiry-type experiments and assessment tools in order to help teachers develop inquiry-teaching skills. It is recommended that professional development strategies focusing on the aims of laboratory work and inquiry teaching and learning are developed to equip teachers with the necessary expertise in designing inquiry oriented laboratory activities that match the aims of laboratory work (Woolnough & Allsop, 1985). It is also recommended that curriculum developers shift from the old and ineffective paper-and-pencil assessment method of students' performance in laboratory work to hands on inquiry oriented assessment methods that are efficient at assessing students' performance (Hofstein, 2004); that a systematic method is developed, through which the enactment of inquiry oriented laboratory instruction can be monitored and evaluated. There were some potential barriers to enactment of inquiry oriented instruction such as limited resources, lack of time and high curriculum demands; which should be addressed to support teachers' use of laboratory instruction.

5.6 Recommendation for further research

Previous studies have focused on finding teachers' and students' perceptions of the aims of laboratory work, and openness of laboratory activities to inquiry (Lynch & Ndyetabura, 1983; Wilkinson & Ward, 1997; Staer et al., 1998). A mismatch was found between teachers' and students' perceptions of laboratory work aims. Laboratory work activities were found to be expository in nature. Recent studies investigated teacher epistemological beliefs and how they influence instructional practices (Wallace & Kang, 2004; Kang & Wallace, 2005). It was found

that teachers' naïve epistemological beliefs were apparent in instructional practice. The current study found that teachers' perceptions of the aims of laboratory work, particularly, conceptual understanding, influence instructional practices. It is recommended that further studies should investigate if teachers' perceptions of the other aims of laboratory work also influence teachers' instructional practices. This will provide sufficient evidence to claim that, teachers' perceptions of the aims of laboratory work influence teachers' decision making on the selection of laboratory instructional practices. It is also necessary to investigate if there is any relationship between junior secondary school teachers' ideas about science and their perceptions of laboratory work.

5.7 Strengths and limitations of the study

In any educational research undertaking there are some strengths as well as limiting factors which might affect the credibility of the study either positively or negatively respectively. One of the strengths of this study is the use of triangulation of sources of data which helped the researcher to establish that the sampled teachers assigned more priority to conceptual understanding as an aim of laboratory work. Secondly the use of a mechanical device to collect interview data has reduced bias.

The sample that was used for this study was too small to be considered representative of the entire population of teachers in Lesotho. For this reason, the conclusions made in this study are only generalizable to the sampled teachers not to Lesotho teachers at large. However these conclusions will be useful to teachers in the other nine districts of Lesotho.

The researcher was a novice in conducting interviews, and this might have affected data collection in one way or another. Interview techniques such as probing might not have been fully exploited and therefore much of the interview data which could have been useful might have been missed. This suspicion was evident in interview transcripts that much detail in some of the teachers' responses seemed missing. It is felt that if the researcher was experienced in conducting interviews, perhaps this could not have been the case. However, the interview data collected provided enough information to answer the research questions.

The validity of observational data is affected mainly by the observer effect on those being observed (Borg & Gall, 1983). The observer was known at the time of observation because it was not possible to make visits prior to conducting the observations. Ideally, the researcher could have visited the classes before making the targeted observations to acquaint himself with the teachers and students in the classroom context so as to reduce the observer effect. However, informal meetings with the teachers briefing them on the purpose of the observations, together with the introduction of the researcher to the students prior to observations have contributed towards reducing threats to the validity of observational data.

5.8 Conclusion

In this chapter the following conclusions were made based on findings from the study: The teachers believe that laboratory work is important for deep understanding of theory; the teachers offer verificationist laboratory activities and use non-inquiry laboratory instruction; and that teachers' perceptions of laboratory work are linked to their instructional practices. Recommendations made for teaching are that teachers should design investigative and problem solving laboratory activities, instead of cookbook activities, so that students develop investigative and problem solving skills. It was also recommended that science curriculum be reviewed to provide teachers with understanding of the aims of laboratory work, and inquiry teaching and learning, and that, potential barriers to practice of inquiry instruction be addressed. The strengths and weaknesses of the study were discussed. It has been recommended that further research should investigate how teachers' perceptions of the aims of laboratory work, other than conceptual understanding, influence laboratory instructional practices.

REFERENCES

Abd-El-Khalick, F., Boujaoude, S., Duschl, R., Lederman, N., Mamlok-Naaman, R., Hofstein, A., Niaz, M., Reagust, D. and Tuan, H. (2004). Inquiry in science education: international perspectives, *Science Education*, 88 (3), 397-419.

Abraham, M. R. (1982). A Descriptive Instrument for use in Investigating Science Laboratories. *Journal of Research in Science Teaching,* 19(2), 155 - 165.

Abrahams, I. and Millar, R. (2008). Does practical work really work? A study of the effectiveness of practical work as a teaching and learning method in school science. *International Journal of Science Education*, 1, 1-25, iFirst Article.

Abrahams, I. and Saglam, M. (2009). A study of teachers' views on practical work in schools in England and Wales. *International Journal of Science Education, 1, 1-16*, iFirst Article.

Akinoglu, O. and Tandogan, R. O. (2007). The effects of problem-based active learning in science education on students' academic achievement, attitude and concept learning. *Eurasia Journal of Mathematics, Science & Technology*, 3 (1), 71-81.

Al-Naqbi, A. K. and Tairab, H. H. (2005). The role of laboratory work in school science: Teachers' and students' perspectives. *Journal of Faculty of Education*, 18 (22), 19-35.

Ary, D., Jacobs, L. C. and Razavieh, A. (1990). *Introduction to Research in Education* (4th ed.). London: Holt, Rinchart and Winston, Inc.

Beatty, J. W. and Woolnough, B. E. (1982). Practical Work in 11-13 Science: the context, type and aims of current practice. *British Educational Research Journal*, 8 (1), 23-30.

Bennett, J. (2005). *Teaching and Learning Science*. London: Continuum International Publishing Group, 73-98.

Best, W. J. and Kahn, V. J. (1998). *Research in Education*. London: Allyn and Bacon.

Borg, W. R. and Gall, M. D. (1983). *Educational Research: An introduction* (4th ed.). London: Longman.

Burton, N., Brundrett, M. and Jones, M. (2008). *Doing your Educational Research Project*. London: SAGE.

Bybee, R. (2000). *Teaching science as inquiry*. In J. Minstrell & E. van Zee (Eds.), Inquiring into inquiry learning and teaching in science, pp. 20-46. (Washington DC, American Association for the Advancement of Science).

Catsambis, S. (1994). The path to math: Gender and racial-ethnic differences in mathematics participation from middle school to high school. *Sociology of Education*, *67*(3), 199–215.

Cheung, D. (2007). Facilitating chemistry teachers to implement inquiry-based laboratory work. *International Journal of Science and Mathematics Education*, 6, 107-130.

Cohen, L., Manion, L. and Morrison, K. (2000). *Research Methods in Education* (5th ed.). London: Routledge Falmer.

Cronin-Jones, L. L. (1991). Science teacher beliefs and their influence on curriculum implementation: Two case studies. *Journal of Research in Science Teaching*, 28(3), 235-250.

Cuevas, P., Lee, O., Hart, J. and Deaktor, R. (2005). Improving Science Inquiry with Elementary Students of Diverse Backgrounds. *Journal of Research in Science teaching,* 42 (3), 337-357.

Domin, D. S. (1999). A Review of Laboratory Instruction styles. *Journal of Chemical Education*, 76 (4), 543-547.

Domin, D. S. (2007). Students' perceptions of when conceptual development occurs during laboratory instruction. *Chemistry Education Research and Practice*, 8 (2), 140-152.

Fenstermacher, G. D. and Richardson, V. (2000). *On making determinations of quality in teaching*. A paper prepared at the request of the Board of International Comparative Studies in Education of the National Academy of Sciences. *Christian Science Monitor,* July 11, 2000.

Fraenkel, J. and Wallen, N. (1990). *How to design and evaluate research in education*. New York: McGraw Hill.

Fraser, B. J. (1998). Classroom Environment Instruments: development, validity and application. *Learning Environments Research*, 1(1), 7-33.

Gall, M. D., Borg, W. R. and Gall, J. P. (1996). *Educational research: an introduction*, 6th ed. White Plains, NY: Longman.

Gardiner, P. and Farragher, P. (1999). The quantity and quality of biology work in British Colombia high schools. *School Science and Mathematics*, 1-10.

Garnett, P., Garnett, J. and Hackling, M. W. (1995). Students' Alternative Conceptions in Chemistry: A Review of Research and Implications for teaching and Learning. *Studies in Science Education*, 25 (1), 69-96.

Gott, R. and Duggan, S. (2002). Problems with the assessment of performance in practical science: Which way now? *Cambridge Journal of Education,* 32 (2), 183-201.

Gwimbi, M.E. and Monk, M. (2003). Study of Classroom Practice and Classroom Contexts amongst Senior High School Biology Teachers in Harare, Zimbabwe. *Science Education,* 25 (4), 467-488.

Hart, C., Mulhall, P., Berry, A., Loughran, J. and Gunstone, R. (2000). What is the purpose of this experiment? Or can students learn something from doing experiments? *Journal of Research in Science Teaching*, 37 (7), 655-675.

Hashweh, M. Z. (1996). Effects of science teachers' epistemological beliefs in teaching. *Journal of Research in Science Teaching*, 33 (1), 47-63.

Hatch, J. A., (2002). *Doing qualitative research in educational settings.* SUNY. New York, 147-210.

Haury, D.L. (1993). *Teaching Science Through Inquiry*. ERIC/ CSMEE Digest.

Herrenkohl, L. R. and Guerra, M. R. (1998). Participant Structures, Scientific Discourse, and Student Engagement in Fourth Grade. *Cognition and Instruction,* 16 (4), 431-473.

Hodson, D. (1990). A critical look at practical work in school science. *School Science Review, 70 (256)*, 33-40.

Hodson, D. (1992). Assessments of practical work; some considerations in philosophy of science. *Science & Education*, 1, 115-144.

Hodson, D. (1993). Re-thinking old ways: Towards a more critical approach to practical work in

school science. *Studies in Science Education*, 22 (1), 85-142.

Hodson, D. (1996). Practical work in school science: Exploring some directions for change. *International Journal of Science Education*, 18 (7), 755-760.

Hodson, D. (2001). *Research on practical work in schools and Universities. In pursuit of better questions and better methods.* Proceedings of the 6th European Conference on Research in Chemical Education, University of Aveiro, Aviero, Portugal.

Hodson, D. (2005). Teaching and learning chemistry in the laboratory: A critical look at the research. *Educacion Quimica*, 16 (1), 60-68.

Hofstein, A. (2004). The laboratory in chemistry education: Thirty years of experience with developments, implementation, and research. *Chemistry Education: Research and Practice,* 5 (3), 247-264.

Hofstein, A. and Lunetta, V. N. (1980). *The role of the laboratory in science teaching: Research implications.* Paper presented at the annual meeting of the National Association for Research in science Teaching (53rd, Boston, MA, April 11-13, 1980).

Hofstein, A. and Lunetta, V. N. (1982). The role of the laboratory in science teaching: Neglected aspects of research. *Review of Educational Research*, 52 (2), 201-217.

Hofstein, A. and Lunetta, V. (2004). The laboratory in science education: Foundations for the twenty-first century, *Science Education*, 88 (1), 28-54.

Hofstein, A. and Mamlok-Naaman R. (2007). The laboratory in science education: The state of the art, *Chemistry Education Research and Practice*, **8**, 105-107.

Jenkins, E.W. (1998). *The schooling of laboratory work.* In J.J. Wellington(Ed.), Practical work in school science. Which way now? (pp. 35–51). London: Routledge.

Jenkins, E. W. (2000). Constructivism in school science: Powerful model or the most dangerous intellectual tendency. *Science Education*, 9 (6), 599-610.

Johnstone, A. H. and Al-Shuaili, A. (2001). Learning in the laboratory; some thoughts from the literature. *University Chemistry Education*, 5 (2), 42-51.

Kang, N. and Wallace, C. (2005). Secondary Science teachers' Use of Laboratory Activities: Linking Epistemological Beliefs, Goals, and Practices. *Science Education*, 89 (1), 140-165.

Keys, C. W. and Bryan, L. A. (2001). Co-constructing inquiry-based science with teachers: Essential research for lasting reform. *Journal of Research in Science Teaching*, 38 (6), 631-645.

Kipnis, M. and Hofstein, A. (2007). An Inquiry Laboratory as a Source for Development of Metacognitive Skills. *International Journal of Science and Mathematics Education.* National Science Council, Taiwan.

Lederman, N. G. (1998). The state of science education: Subject matter without context. *Electronic Journal of Science Education*, 3 (2). (Available online http://unr.edu/ homepage/jcannon/ejse/lederman.html)

Lynch, P .P. and Ndyetabura, V. L. (1983). Practical Work in Schools: An Examination of teachers Stated Aims and the Influence of Practical Work According to Students. *Journal of Research in Science Teaching*, 20 (7), 663-671.

Malterud, K. (2001). Qualitative research: standards, challenges, and guidelines. *The Lancet,* 358: 483-488.

McMillan, J. H. and Schumacher, S. (2006). *Research in Education: evidenced-based inquiry* (6th ed.) Boston: Allyn and Bacon.

Millar, R. (2004). *The role of practical work in the teaching and learning of science*. Paper presented to the committee: High School Science Laboratories: Role and Vision, National Academy of Sciences, Washington DC.

Ministry of Education and Training. (2006). *Lesotho Junior secondary science syllabus*. NCDC. Maseru.

National Research Council. (1996). *National Science Education Standards*. Washington, DC: National Academy Press.

Opie, C. (2004). Research Procedures. In C. Opie, (Ed.), *Doing Educational Research. A Guide to first Time Researchers*. London: SAGE.

Ottander, C. and Grelsson, G. (2006). Laboratory work: the teachers' perspective. *Journal of Biology Teaching*, 40 (3), 113-118.

Phakisi, M. E. (2008). Factors affecting the implementation of the new junior secondary science curriculum in Lesotho. Unpublished M Sc. Thesis - University of the Witwatersrand, 2008.

Pekmez, E. S., Johnson, P. and Gott, R. (2005). Teachers' understanding of the nature and purpose of practical work. *Research in Science & technological Education*, 23 (1), 3-23

Poliah, R. R. (1993). A survey of the perceptions and attitudes of pupils and teachers to biology practical work in Indian secondary schools in the PWV area in the Traansvaal. Unpublished M ED Thesis, University of the Witwatersrand, Johannesburg.

Ravitz, J. L., Becker, H. J. and Wong, Y. (2000). Constructivist-Compatible Beliefs and Practices among U.S. Teachers Teaching, Learning, and Computing: 1998 National Survey Report #4. Centre for Research on Information Technology and Organizations, University of Carlifornia, Irvine And University of Minnesota.

Roberts, R. and Gott, R. (2004). A written test for procedural understanding: a way forward for assessment in the U.K science curriculum. *Research in Science & Technological Education,* 22 (1), 5-21.

Roth, W. M. (1994). Experiments in a constructivist high school physics laboratory. *Journal of Research in Science teaching,* 31, 197-223.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher,* 15 (2), 4-14.

Songer, N. B., Lee, H. and McDonald, S. (2003). Research Towards an Expanded Understanding of Inquiry Science Beyond One Idealized Standard. *Science Education*, 87 (4), 490-516.

Staer, H., Goodrum, D. and Hackling, M. (1998). *Research in Science Education,* 28 (2), 219-228.

Straub, D. W., Boudreau, M.-C. and Gefen, D. (2004). Validation Guidelines for IS Positivist Research. *Communications of* AIS (forthcoming), 1-70.

Supovitz, J. A., Mayer, D. P. and Kahle, J. B. (2000). Promoting inquiry-based instructional practice: The longitudinal impact of professional development in the context of systemic reform. *Educational Policy*, 14 (3) 331-356.

Swain, J., Monk, M. and Johnson, S. (1999). Acomparative study of attitudes to the aims of practical work in science in Egypt, Korea and the UK. *International Journal of science Education*, 21(12), 1311-1324.

Tan, A. (2008). Tensions in the Biology Laboratory: What are they? *International Journal of Science Education*, 1-16, iFirst Article.

Teijlingen van, E. and Hundley, V. (2001). The Importance of Pilot Studies, *Social Research Update*, Department of Sociology, University of Surrey, 35.

Tobin, K. and Fraser, B. J. (1998). Qualitative and Quantitative landscapes of classroom learning environments. In B. Fraser & K. Tobin (Eds.). *International handbook of science education*. Dordrecht: Kluwer.

Tobin, K. and McRobbie, C. (1996). Cultural myths as constraints to the enacted science curriculum. *Science Education*, 80, 223-241.

Trumbull, D. and Slack, M. J. (1991). Learning to ask, listen, and analyze: using structured interviewing assignments to develop reflection in pre-service science teachers. *International Journal of Science Education*, 13 (2), 129-142.

Tsai, C-C. (1999). 'Laboratory exercises help me memorize the scientific truths': A study of eighth graders' scientific epistemological views and learning in laboratory activities. *Science Education*, 83(6), 654-674.

Tsai, C. (2002). Nested epistemologies: science teachers' beliefs of teaching, learning, and science. *International Journal of Science Education*, 24 (8), 771-783.

Tsai, C. (2003). Taiwanese science students' and teachers' perceptions of the laboratory learning environments: exploring epistemological gaps. *International Journal of Science Education*, 25 (7), 847-860.

Vhurumuku, E. (2001). A comparison of teachers' and students' rankings of practical work objectives in 'A' level chemistry. *Zimbabwe Journal of Educational Research*, 13 (2), 154-176.

Vhurumuku, E. (2004). An Investigation of Zimbabwe A-level Chemistry Teachers' Epistemological Beliefs, Laboratory Instructional Practices and Students' Images of the Nature of Science. Unpublished Doctoral Dissertation, University of the Western Cape, South Africa.

Vhurumuku, E., Holtman, L., Mikalsen, O. and Kolsto, S. D. (2006). An Investigation of Zimbabwe High School Chemistry Students' Laboratory Work - Based on Images of the Nature of Science. *Journal of Research in Science Teaching*, 43 (2), 127-149.

Vhurumuku, E. (2009). Scientific Epistemologies and Classroom Inquiry: To what extent do teachers put their beliefs into practice? *Association of Science Teacher Education ASTE 2009 International Conference*, University of Connecticut, Hartford, USA, January 8-10, 2009.

Tsai, C. (2007). Teachers' scientific epistemological views: The coherence with instruction and students' views. *Science Education*, 91, 222-243.

Wallace, C. S. and Kang, N. (2004). An investigation of experienced secondary science teachers' beliefs about inquiry: An examination of competing belief sets. *Journal of Research in Science Teaching,* 41 (9), 936-960.

Wellington, J. (1998). *Practical Work in Science: time for re-appraisal,* in: J. Wellington (Ed.) Practical work in school science: which way now? (London, Routledge).

Windschitl, M. (2003). Inquiry Projects in science Teacher Education: What Can Investigative Experiences Reveal About Teacher Thinking and Eventual Classroom Practice. *Science Teacher Education,* 87: 112-143.

Woolnough, B. and Allsop, T. (1985). *Practical work in science.* Cambridge: Cambridge University Press.

Yildiz, E., Akpinar, E., Aydoğdu, B. and Ergin, Ö. (2006). Science teachers' attitudes towards aims of the science experiments. *Journal of Turkish Science Education*, 3 (2), 2-6.

APPENDIX A

Teachers' Perceptions of Aims of Laboratory Work Questionnaire (TPALW)

(Adapted from Wilkinson & Ward, 1997)

NB. All the information given in this questionnaire will be treated in strict confidence.

This questionnaire has three sections.

SECTION A

Gender…….

Age…….

For how long have you taught…….

Qualification…….....

Classes taught (J.C)……

Specialization subjects……...

SECTION B

Instructions:

The table below shows ten possible aims of laboratory work. Rank the ten aims by indicating with a tick (√) in the table, whether each of the aims is **Not important, Important, or Very important.**

Aim of Laboratory Work	Not important	Important	Very important
1. To gain practice at making accurate observations and interpreting them			
2. To promote thinking in a scientific way			
3. To gain experience in using scientific equipment			
4. To give training in solving problems and conducting investigations			
5. To help students understand theoretical parts of science			
6. To give practice in following a set of instructions			
7. To enable students to discover or verify facts and ideas for themselves			
8. To make science more interesting and enjoyable through actual experience			
9. To develop skills in working cooperatively with others			
10. To develop an understanding of the nature of science			

SECTION C

INSTRUCTIONS:

The table below shows four major aims of laboratory work. Indicate with a tick (√) in the appropriate box, whether each of the aims is **Not important, Important, or Very important.**

Major aim of laboratory work	Not important	Important	Very important.
1. Development of conceptual understanding of theory			
2. Promoting interest and motivation in science			
3. Development of process skills and techniques			
4. Development of an understanding of the nature of science and scientific inquiry			

APPENDIX B

Teachers' Perceptions of Instruction Questionnaire (TPI)

(Adapted from Abraham, 1982)

Instructions:

This questionnaire is about how often the statement given occurs **during your science lesson teaching**. Your responses should be based on your use of **laboratory work during teaching**. By ticking (**√**) in the appropriate box, indicate how often what is described by each statement happens.

Item No	Statement	1 Almost never	2 Seldom	3 Sometimes	4 Often	5 Almost always
1	I ask students to follow step by step instructions in the laboratory guide or worksheet					
2	The experiment reports written by students require interpretation of data					
3	The teacher is always concerned with the correctness of results					
4	Laboratory experiments are used by the teacher to help students understand scientific ideas					
5	The teacher lectures to the whole class.					
6	The teacher asks students to design their own experiments					
7	The teacher allows students to go beyond regular laboratory exercises and do experiments on their own					
8	Laboratory practical sessions raise new problems or a result that cannot be easily explained by students					
9	During practical work students record information requested by the teacher or the laboratory assistant					
10	The teacher identifies the problem to be investigated					

11	Laboratory work requires students to solve problems					
Item No	**Statement**	**1 Almost never**	**2 Seldom**	**3 Sometimes**	**4 Often**	**5 Almost always**
12	Laboratory reports require students to answer specific questions					
13	The teacher requires students to explain why certain things happen					
14	Students use the laboratory to investigate a problem that comes up in class					
15	The experiments students do help them develop skills, techniques and procedures of science					
16	Laboratory experiments reports require students to use evidence to back up the conclusions they make.					
17	Laboratory experiments reports require students to use evidence to back up the conclusions they make.					
18	The teacher asks students questions to state alternative explanations for observed phenomena					
19	During practical work students record information they feel is important					
20	Students propose their own explanations to observed phenomena					
21	Students identify problems to investigate					
22	During practical work students check the correctness of their work with the teacher					
23	In discussion with the teacher students challenge assumptions and want conclusions justified					
24	Students usually know what is expected of an experiment before doing the experiment					
25	The teacher gives information to individual students in small groups					

APPENDIX C

Open Ended Questionnaire

1. Do you think laboratory work is important for teaching science? Explain your answer.

……

……

……

……

2. How many times do you do an experiment with a class of students per week?

.....

Does your laboratory have enough/ adequate equipment and/or materials? Give details.

.....

.....

4. What do you think is the role and use of experiments in teaching science?

.....

.....

.....

.....

5. In your teaching, what do you use laboratory work for?

……

……

……

…….....

6. What are the major difficulties you encounter when using laboratory work for teaching science?

……

……

……

…….....

APPENDIX D

Interview Schedule

Section A

Teachers' perceptions of the aims of laboratory work

1. Do you have a laboratory in your school?
2. Can you say something about your experiences in using laboratory work (practical work) for teaching?
3. Almost all schools in Lesotho have a laboratory. Do you think it is necessary to have a laboratory at every school? Why or Why not?
4. What do you use laboratory work for? I mean what goals do you aim to achieve when you use laboratory work?
5. What do you think students can learn from doing laboratory work?
6. According to you what are the most important aims of laboratory work?
7. Can students learn to be like scientists by doing experiments?

Section B

Teachers' use and practices in laboratory work

1. Do you think the experiments you do with your learners are similar to what real scientists do?
2. How often do you do experiments with your classes?
3. What problems do you normally encounter when using laboratory work for teaching?
4. How do you organize your laboratory activities? Group work? Individual work? What is your role during laboratory activities?
5. In your opinion, what should teachers do to ensure successful use of laboratory work in teaching science?
6. Where do you obtain laboratory activities/experiments that you give to your students?

7. Do your students sometimes design their own experiments? Do you think it is important that students design their own experiments? Explain
8. Can you say you enjoy doing experiments with your class? Why and why not?
9. Can you briefly describe your science teaching experiences?
10. I would like you to read the following incidents and explain how you would respond to each incident.

Incident #1

A class of **Form C (grade 9)** is heating magnesium ribbon in a crucible with a lid. The purpose of the lesson is to test the consequence of oxygen theory that materials gain weight when they are burnt. At the end of the lesson, 4 groups report a loss in weight, 2 groups report no difference, and 2 groups a gain in weight.

Incident # 2

Form A (grade 7) students are doing experiments with circuit boards. With two bulbs in series, many students find that one bulb is lit brightly while the other bulb appears to be unlit.

APPENDIX E

Laboratory Observation Schedule

Name of school……

Name of Teacher…….

Class taught……

Date……..

Aim of laboratory work.....

……

Source of Laboratory Work……..

……

Introduction:……..

……

……

Body of lesson…….....

……

……

Conclusion……

……

……

Post lab exercises……

……

……

Questioning techniques……

……

……

Organization of lab- individual/group/pairs……...

……

Distribution of materials……

……

……

What happens - lab noise levels?

.....

……

……

Student-student interactions…….

……

……

Student-teacher interactions……..

……

……

Approach used: verification of knowledge; discovery; problem solving; investigation; closed lab; open ended investigation; ……..

……

Availability of resources chemicals; apparatus; ……...

……

……

Assessment and evaluation of students……

……

……

Self-criticism by teacher……

……

……

Post lesson interview:

What makes you decide to use a laboratory activity?

.....

……..

……..

Why did you decide to use the teaching method you used?

.....

……

……..

Do you always teach like this?

.....

……..

……...

How do you think students have benefitted from this method?

……

……

……

Did you have any constraints in doing this lab work?

……

……

……

APPENDIX F

University of the Witwatersrand
Private Bag 3
P.0. Box Wits, 2050
5 June, 2008.

The Education Inspector
Ministry of Education and Training
P.0. Box 47, Maseru, 100, Lesotho
Dear Sir/Madam;

RE: Application for conducting a research study in Lesotho schools

I am currently a Master of Science student registered with the University of the Witwatersrand in the school of Education in Johannesburg. In partial fulfillment of the requirements for the degree of Master of Science, I am required to submit a research report.

To this effect, I apply for permission to undertake a research study in Lesotho schools in the Butha-Buthe district. The purpose of the study is *to investigate Lesotho junior secondary school science teachers' attitudes and use of laboratory work.*

The significance of the study is that it will inform curriculum planning for teacher education and also inform better ways to support teachers' effective use of laboratory work. Fifty (50) teachers will be required to participate in the study by completing questionnaires. Some of the teachers who answered the questionnaires will be interviewed. Laboratory observations involving some of the interviewed teachers will be conducted. The School of Education Ethics Committee has carefully considered my research study and is satisfied that it conforms to the principles set out in the University's Code of Ethics for Research on Human Subjects.

Thank you for your anticipated cooperation in this regard.
Yours Faithfully,

Monare Thulo Julius.
Student Number: 0701926M

APPENDIX G

Interview Transcripts

Interview transcript for *Teacher A* at Thabong High School (24/03/09)

1	**Teachers' perceptions of the aims of laboratory work**
2	
3	**R:** Thank you very much for giving me this opportunity to interview you. My
4	questions are divided into two categories, the first being on teachers' perceptions of
5	the aims of laboratory work and the second category on teachers' use and practices in
6	laboratory work. By laboratory work I mean practical work that students engage in the
7	learning of science. Practices in laboratory work refer to laboratory instructional
8	practices that the teacher employs in the laboratory. Now the first question I have for
9	you is this one;
10	Do you have a laboratory in your school?
11	**TA:** Yes sir, we have it, the one in which we are right now.
12	**R:** Yes I can see (both laughing). The second question; Can you say something about
13	your experiences in using laboratory work or practical work in the teaching of science.
14	**TA:** Eh! I think the laboratory is meant to help students to learn science, although
15	more often than not we as teachers do not use the laboratory effectively, but prefer to
16	use the classroom even when the concept that I am teaching needs the use of the
17	laboratory. In our school I and my colleagues have agreed that we should try as much
18	as we can to use the laboratory whenever we teach content that requires the use of the
19	laboratory or apparatus in the laboratory.
20	**R:** O.K. Almost all secondary and high schools in Lesotho have laboratories. Do you
21	think it is necessary that each and every school should have a laboratory?
22	It is necessary because in order to make students enjoy or love science they must be
23	able to manipulate scientific equipment. Unless they can manipulate objects, they will
24	not be able to understand what they learn because most science concepts are abstract.
25	…

Interview transcript for *Teacher B* at Mofoka High School (24/03/09)

Line No.	Interview Transcript
1	**Teachers' perceptions of the aims of laboratory work**
2	
3	**R:** Thank you sir, for allowing me this opportunity to use your valuable time to
4	interview you. Eh! The questions I would like to ask you fall into two categories. The
5	first category is of teachers' perceptions of the aims of laboratory work, where
6	laboratory work means practical work in the teaching and learning of science. Eh! The
7	second category of questions is on teachers' use and practices in laboratory work. Let
8	us start with the first category.
9	Eh! Do you have a laboratory in your school?
10	**TB:** Yes, we have a laboratory.
11	**R:** O.K. Can you say something about your experiences in using laboratory work in
12	the school?
13	**TB:** The use of laboratory is to make this science subject easy for the students to
14	understand as most of the science concepts seem to be more abstract for the kids when
15	they are just mentioned theoretically, and the kids begin to be more interested when
16	they find that they see some of these things happening and they understand them
17	better.
18	**R:** O.K. Which means that you say that laboratory work promotes conceptual
19	understanding? That is, the concepts learned in class will be better understood during
20	laboratory work?
21	**TB:** Yes.
22	**R:** Almost all schools in Lesotho have a laboratory. Do you think it is necessary for all
23	the schools to have laboratories? Or laboratories should be present in certain schools?
24	**TB:** Eh! I think the schools that fall under the same level like we are talking about J.C
25	or secondary schools, it is very necessary that they should have laboratories. …

Interview transcript for *Teacher C* at Mabalane High School (26/03/2009)

Line No.	Interview transcript
1	**Teachers' perceptions of the aims of laboratory work**
2	
3	**R:** Thank you very much sir, for allowing me this opportunity to take your valuable time
4	to interview you. My questions for this interview have been divided into two sections and
5	the first section is about teachers' perceptions of the aims of laboratory work. The second
6	section is based on teachers' use and practices in laboratory work. By laboratory work I
7	refer to practical work done in the teaching and learning of science, and by practices I
8	refer to instructional practices or simply laboratory teaching. Now let us look at the first
9	section. The first question is as follows:
10	Do you have a laboratory in your school?
11	**TC:** yes, it is there.
12	**R:** Can you say something about your experiences in using laboratory work in your
13	teaching.
14	**TC:** O.K. Actually my experience in using the laboratory when teaching has taught me
15	many things. I realized that some students understand when they see things happening. So
16	an experiment that is used in the laboratory can aid most of them to have concrete
17	understanding rather than abstract thinking.
18	**R:** Do your students enjoy the laboratory?
19	**TC:** Sometimes. If the laboratory experiment is interesting, then they enjoy it a lot. But if
20	it is actually not interesting to them they take it as a play.
21	**R:** Almost all schools in Lesotho have a laboratory. Do you think it is necessary to have a
22	laboratory at every school?
23	**TC:** Really it is necessary.
24	**R:** Can you explain briefly why you think it is necessary. …

Interview transcript for Teacher D at Selibeng High School (26/03/2009)

Line No.	Interview Transcript
1	**Teachers' perceptions of the aims of laboratory work**
2	
3	**R:** Thank you very much for allowing me your valuable time to interview you. My
4	questions are divided into two sections. The first section consists of questions on
5	teachers' perceptions of the aims of laboratory work, while the second section is on
6	teachers' use and practices in laboratory work. Laboratory work here refers to
7	practical work in the teaching and learning of science whereas practices refer to
8	laboratory instruction. The first question I have for you is this one:
9	Do you have a laboratory in your school?
10	**TD:** Yes we do.
11	**R:** can you say something about your experiences in using laboratory work in your
12	school?
13	**TD:** The challenges are that you have to plan your work in the laboratory, and the
14	plan does not only mean writing down but also means performing the experiment
15	before taking students to the laboratory. So, that needs a lot of time. Now, eh!
16	Actually that is one thing that makes people not to prepare well, because of the time
17	one should give for preparation for that particular lesson in the laboratory.
18	**R:** Can you also say anything about successes or problems?
19	**TD:** The successes, yes there is another fact. In fact when students have seen things
20	in the laboratory, when they have touched and observed things in the laboratory, their
21	understanding is broadened; they understand better.
22	**R:** What do you think about skills? Does it develop any skills in students?
23	**TD:** Yes, in fact in most cases. We do ask students to perform experiments
24	themselves, we prepare some material which will guide them in performing the
25	experiment and that helps them to do things themselves. So I think. …

Interview transcript for *Teacher E* at Kanana High School (27/03/2009)

Line No.	Interview Transcript
1	**Teachers' perceptions of the aims of laboratory work**
2	
3	**R:** Thank you for allowing me your time to interview you. For this interview the
4	questions are divided into two sections. The first section is on teachers' perceptions
5	of the aims of laboratory work. By laboratory work I mean all practical work that is
6	done in the teaching and learning of science. The second section is on teachers' use
7	and practices in laboratory work. By practices I mean instructional practices or
8	laboratory teaching. The first question I have for you is this one:
9	Do you have a laboratory in your school?
10	**TE:** Yes, we have one.
11	**R:** Can you say something about your experiences in using laboratory work? By
12	experiences is meant problems, successes or challenges you experienced in using
13	laboratory work.
14	**TE:** O.K. in the first place if I may talk about the problems which one encounters
15	when using laboratory work is that it is true that we have a laboratory but when one
16	wants to use it you will find that there is not enough equipment, with which we want
17	to equip the students. So in most cases you will find that if you want to involve the
18	students in the work, the teacher is forced to demonstrate. In other words the students
19	are not much involved. That is, they do not have that much to manipulate on their
20	own just because of lack of equipment. On the successes I may say that the few we
21	have really help us a lot. When one considers the instruments; there are some
22	instruments which help the students although you will find that the students do not
23	know much about the instruments , but when they are in the laboratory it is where
24	they are shown the instruments and they become interested in what they see.
25	**R:** Almost all schools in Lesotho have a laboratory. Do you think it is necessary…

APPENDIX H

Information Sheet

Research Study on "Lesotho Junior Secondary Science teachers' Attitudes and Use of Laboratory Work"

I am a **Master of Science (Science Education) student** studying at the **University Of The Witwatersrand** in Johannesburg.

The purpose of this study is to investigate Lesotho junior secondary science teachers' attitudes and use of laboratory work. The study will inform curriculum planning for teacher education and also teaching at the secondary school level. It will also inform better ways to support teachers' effective use of laboratory work.

I would like you to take part in the study intended for this investigation. I am particularly desirous of obtaining your responses because your information will contribute significantly in addressing some of the problems associated with laboratory work.

If you agree to take part in my study, I would like to make it clear that your participation is entirely voluntary, no harm will come to you, and all the information will be treated with confidentiality and anonymity. If you do choose to participate, you may decline to answer any questions, and you may withdraw from the study at any time. In order to ensure confidentiality, all names used in my research reports and summaries will be fictitious (made-up).

I will provide you with a summary of my research results on completion if you would like to have them.

Thank you for your anticipated cooperation.

Monare Thulo Julius (Mr).