VALIDATION OF INSTRUMENTS USED TO ESTABLISH PRACTICAL EXPERIENCE IN HIGH SCHOOL CHEMISTRY

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A research report submitted to the Faculty of Science, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the Degree of Master of Science.

DECLARATION

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

Khoali

T.J. KHOALI

4 **day of** JUNE **, 2001**

Abstract

It is essential for learners to have practical experience as this will equip them with cognitive and manipulative skills, acquisition of an academic attitude to working. It is the only way of experiencing at first hand many of the phenomena and events that science addresses. This study aims to establish the validity of a questionnaire consisting of three existing instruments used to probe high school students' chemistry practical experience. Two aspects of practical experience that are being looked at are: a general practical experience which consists of what students say about their levels of exposure to experimental work; and specific remembered practical experience. Specific remembered practical experience is established through the extent to which students are able to name and describe the use of standard laboratory apparatus they have actually used in school practical work. The three instruments have been used in the past to measure students' practical experience, and though piloted, were never validated. Each instrument was administered in the form of a questionnaire to Grade 12 students in 4 schools. The 4 schools were selected as a stratified sample. Sixteen students from the 4 schools were interviewed as a follow up. Instrument 1 (the primary instrument) which consisted of 10 pictures of common chemistry apparatus was validated using the interview responses. Instrument 1 was then used to validate the other two instruments. Findings show that the instrument 1 was valid overall, but could not establish whether students had teacher demonstrations or not. Some inconsistencies were identified with the other two instruments. Therefore, instrument 2 and 3 were found not valid. Some suggestions for the improvement of instrument 1 are offered.

DEDICATION

Dedicated to my mother 'Matsokolo Khoali who through her inspiration instilied within me perseverance and ambition.

My wife 'Mateboho and our daughters, Teboho and Relebohile Khoali with all the support they gave me.

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My sincere gratitude extended to Professor Marissa Rollnick and Doctor Abdool Bapoo my supervisors for their patience, invaluable assistance, constructive criticism and guidance without which this study would have been impossible.

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I would also like to thank my friends Thabiso Nyabanyaba and Frackson Mumba, and all the members of research group for their support.

Finally, I would like to thank the Lord for His guidance, protection and help during this study.

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AN INTRODUCTION TO THE PROBLEM, AND AN OVERVIEW OF RESEARCH

1. Introduction

This study looks at the validity of instruments used to probe chemistry practical experience that high school students bring with them to the beginning of their first year science studies at university. The practical experience is looked at from two points of view: general practical experience which consists of what students say about their levels of exposure to experimental work, and specific remembered practical experience. The latter is established through the extent to which students are able to name and describe the use of standard laboratory apparatus, while with the former, students were asked to give views, orally (during interviews) and in written form, about their practical experience.

Students may have had hands-on experience with the laboratory apparatus, either in an individual or group situation, or watched the teacher doing some demonstrations with or without students' help. There are many different views about what practical work is as Yager (1991:p.22) asserts that, " practical work is often defined as typical laboratory work where students encounter ideas and principles at first hand; to some it merely means 'hands-on' science."

1.1 Problem and its setting

1.1.1 Background to the problem

Data on research done in South Africa on practical activities reveals that the issue of science practical activities at high school is not seriously considered by teachers (Naik, 1996), and hence students encounter some difficulties when they get to university (Rollnick *et al.*, in press, and Buffler *et al.*, 1998). Research also reveals that a large number of students who come from educationally disadvantaged sectors of the schooling system are likely to encounter practical work for the first time on entering the laboratory at university (Buffler *et al.*, 1998). There are a number of possible reasons for this state of affairs: insufficient provision of laboratories -

especially in the rural areas; lack of supplies like electricity, running water, gas, laboratory equipment and apparatus (Bot, 1997). A large number of students in a class, time-table constraints; lengthy syllabi and shortage of qualified teachers could also prove to be a stumbling block in as far as implementing practical work at high school level is concerned (Naik, 1996).

According to some science educators another factor could be that there is no compulsion from the educational authorities to force teachers to do practical work, hence it is neglected. It is common practice that the intended curriculum - which is often described in detail - never comes out as it is written in schools (Taylor and Vinjevold, 1999). This implies that the delivered curriculum will vary from school to school and is often examination driven. In other words it is influenced by the kind of examinations that are written at the schools.

1.1.2 Statement of the problem

In- coming first year science students, at the University of the Witwatersrand (Wits) come from different educational backgrounds and hence they have different levels of practical experiences. Several instruments have been used to determine these experiences but, the validity of these instruments has not yet been established. This research tries to determine the validity of existing instruments in establishing practical experience in high school chemistry.

1.2 Purpose of the study

Three instruments have been previously used to establish practical experience of in-coming science students at the University of the Witwatersrand. One of these instruments, the primary instrument, was used by Rollnick *et al.* (1999); the second instrument was used in the Physics Department at the University of Cape Town (Kaunda and Ball, 1998). The third instrument is from the College of Science at the University of the Witwatersrand. None of these has been properly validated.

The findings of this study can be used to develop teaching strategies and to allow meaningful review of laboratory curricula at the University of the Witwatersrand and elsewhere. Also, the findings are necessary for research into the connection between procedural understanding and laboratory experience. Procedural and conceptual understanding will be dealt with in the next chapter.

1.3 Rationale

Students at the University of the Witwatersrand come from different parts of South Africa and other countries. They come from different educational, socio-economic, and cultural backgrounds and may show different aptitudes towards practicals.

Some of these students come from disadvantaged schools and as mentioned above, it is possible that a good proportion of them are likely to encounter practical activities for the first time on entering the laboratory at university level. This lack of experience might be due to lack of funds or lack of capability of science teachers regarding practical activities. From my five years of experience as a teacher, I have realised that some high school teachers do not seem to like laboratory activities, possibly due to lack of confidence because of their lack of qualifications, the context in which they are working, or not being aware of the inductive and deductive components of the nature of science, and perhaps, also unwillingness to do practical work.

In South Africa, data gathered in five provinces (Eastern Cape, KwaZulu-Natal, Mpumalanga, Northern Province and North West) showed that the majority of schools with secondary classes do not have laboratories (Bot, 1997). Bot (1997) asserts that roughly one out of every twenty schools in South Africa is not suitable for education due to conditions of school buildings, and only 43% of schools have some source of electricity. Generally, teachers teach subjects outside their area of specialisation. These are some of the factors that may affect students' education. It is, therefore, very important to be aware of the strengths and weaknesses of in-coming science students as far as practical work is concerned as this informs future teaching strategies and the need for restructuring the laboratory curriculum.

Rollnick *et al.*(1999) believe that there is a connection between practical experience and procedural understanding. Gabel (1999:p.550) argues that "the use of unfamiliar materials in chemistry instruction appears to be an additional barrier to conceptual understanding........" This implies that students' prior knowledge is very important in science teaching just as their practical experience is also important in practical work. In their work, Rollnick *et al.*(1999) developed an instrument for assessing previous laboratory experience. Using this instrument they found some relationship between students' understanding of handling experimental data and previous laboratory experience. However, during this study some doubts were cast on the validity of the instrument. The instrument has never been validated. Against this background this research attempts to validate this and the two other existing instruments.

This research is very important because it is fallacious to assume that in-coming students possess adequate practical experience and also because of the claim made by Rollnick *et al.* (1999) that the extent of experience of practical work influences students' ability to handle data. Hence, there is a need to establish prior practical experiences of in-coming students before they can start with their practical activities at university, as this will help in allowing a meaningful review of laboratory curriculum both at secondary and tertiary levels. Information related to this type of practical experience is only useful if it is acquired by means of reliable and valid instruments.

The type of practical experience these three instruments are attempting to elicit will be described later. Validity of the instruments implies that they can measure actual practical experience. These instruments, although piloted, were never validated. Validating these instruments is very crucial for reasons already mentioned above, hence the need to carry out this study.

1.4 Research questions

This research attempts to answer two main questions.

1. How valid are existing instruments in determining learners' high school chemistry practical experience?

   - To what extent does the information obtained from these instruments tally with their actual experience?
   - How well do the various instruments agree with each other with regard to high school chemistry students' practical experience?

2. How do these instruments discriminate between the different practical experiences that high school chemistry students might have?

1.5 Delineation

In order to limit the scope of the study, only four schools were used in this study; two former Black schools, one former Indian School, and one former White school. Also, only four students and two physical science teachers from each school were interviewed. It will therefore not be possible to generalise the findings as a small sample of students and teachers participated in this study.

Practical work should be done in all the sciences, namely: general science, biology and physical science. This is a wide field and therefore in this study the researcher focuses **mainly** on practical work in chemistry, specifically at Grade 12 level.

1.6 Concluding remarks

This study, besides validating the existing instruments, also wishes to inform biology and physical science teachers as well as the public of what could be the state of practical experience of physical science students in some schools. It also tries to reveal the difference (if any) between students from advantaged schools and those from disadvantaged schools as far as practical work is concerned. An advantaged school, in this context, is the one which has sufficient facilities, for example, laboratories, laboratory apparatus etc., as well as having teachers with sufficient confidence to handle practical work.

1.7 Organisation of the thesis

Chapter 1 discussed validation of existing instruments used to probe practical experience that high school students bring with them to the beginning of their first year science studies at the university. The type of practical experience that study focuses on is also discussed. The chapter also gave the general problem area, the rationale for the study, and the research questions for the study.

Chapter 2 will review literature that is relevant to the study. The literature will be reviewed under the following topics: what is practical work, types of practical work and related aspects, the importance and aims of practical work, some views against practical work, procedural understanding, practical work in South African schools, the need for validity, and ways of measuring experience of practical work. The chapter will end with a discussion of the directions for the research emanating from the literature review.

Chapter 3 will give an overview of how the research was carried out, including the mode of data collection. This includes choosing the sample, contacting the schools, problems encountered, design and instruments, piloting of the instruments, and finally, concluding remarks.

Chapter 4 looks at the analysis of data collected from the student questionnaire and interview sessions with students and teachers. The data will be analised using a coding system adopted from a study by Rollnick *et al.* (1999)

Chapter 5 will discuss the data presented in chapter 4 with the intention to bring together data collected from instrument 1 and the interview sessions of both students and teachers in order to validate instrument 1. After validating instrument 1, it will be used to validate the other two instruments (instruments 2 and 3).

The last chapter, chapter 6 will discuss the findings of the study and then go on to give the conclusions coming out of the study. The chapter will end by making some recommendations and pointing out limitations of the study.

CHAPTER 2

REVIEW OF RELATED LITERATURE

2.0 Introduction

Since the aim of this study is to validate instruments used to establish chemistry practical experience of high school students, aspects related to validity will be alluded to later in this chapter. Firstly, different manifestations of "practical work", some of the research findings related to practical work, with particular focus on students' active participation in science activities, will be reviewed as well as the extent at which secondary schools are involved in practical work particularly in South Africa.

This chapter looks at the aspects of practical work, its description as given by different authors, and the types of practical work particularly teacher demonstrations and student practical work. It also peruses literature on practical work in order to get an insight on what researchers have to say about practical work. That is, getting different views from different people about practical work. For example, the aims and importance of practical work; its advantages and disadvantages, and its impact (if any) on procedural understanding. Lastly, but most important to the current study, is the notion of validity. This chapter will also look critically at different notions of validity, how they link and how they may differ, and identify one (notion) which is relevant to the context of this study. A conclusion on this chapter will be given at the end.

2.1 What is practical work?

2.1.1 Descriptions of practical work

It is not an easy task to come up with one description of what practical work is, as people have different perceptions about it. It has been widely assumed that practical work necessarily means laboratory bench work and that bench work always comprises experimentation (Hodson, 1998). Several authors give various kinds of views as to what they think practical work is.

> *"any learning method that requires learners to be active, rather than passive, accords with the belief that students learn best by direct experience and so could be described*

as practical work." (Hodson, 1993:p.119).

"*contrived learning experience in which students interact with materials to observe phenomena.*" (Hofstein, 1988:p.190).

Kempa and Ward (1975) cited by Hofstein (1988) suggest a four-phase taxonomy to describe the overall process of practical work in science education:

1. *planning and design of an investigation in which the student predicts results, formulates hypotheses, and designs procedures;*
2. *carrying out the experiment, in which the student makes decisions about investigative techniques and manipulates materials and equipment;*
3. *observation of particular phenomena and*
4. *analysis , application and explanation, in which the student process data, discusses results, explores relationships and formulates new problems.*

"*any experiments and observational exercises conducted by the teacher as demonstrations as well as experiments and observational exercises carried out by pupils*" Moodley (1980) cited by Poliah (1993:p.8).

Isaacs (1980) cited by Poliah (1993:p.8) provides a more comprehensive definition,

"*The term practical work refers to all kinds of observational, investigative 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.*"

"*all those kinds of learning activities in science which involve students at some point in handling or observing real objects or materials (or direct representation of these, in a simulation or video-recording)*" (Millar *et al.*,1999:p.36).

By including the words 'at some point' in the definition above, Millar *et al.*(1999) emphasises the idea that practical work involves conceptual activity as well as practical activity, so that observing or handling objects and materials is just one element of practical task. The definition also includes teaching and learning activities in which the students watch someone else (often the teacher) handle objects or materials, as well as those in which they [students] handle them for themselves. That is, it includes teacher demonstrations as well as pupil practical work. Due to modern technology, there are also activities in which students worked with representations of real *as practical work."* (Hodson, 1993:p.119).

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Of all the given descriptions one is influenced to conclude that Isaacs'(1980) and Millar *et al.* (1999) are the most comprehensive as far as practical work in most schools is concerned. According to research, practical work in most schools in many countries consists of more teacher demonstrations and group-work by students (Klainin, 1988). Individual activities are not common because of insufficient supply of resources and the huge number of learners per class (Klainin, 1988; Millar *et al.* 1999). Isaacs'(1980) and Millar *et al.* (1999) definitions closely describe the kind of practical work this study is concerned with, which has already been mentioned in the previous chapter.

Millar *et al.* (1999) portrays practical work in a much broader way by trying to describe more closely the nature of the laboratory task. In their definition, they imply "a wide range of laboratory environments, from working with a CD-ROM to collecting living organisms outdoors" (Rollnick *et.al.*, unpublished). According to Rollnick *et al.*(unpublished) these extremes are both far from the traditional view of practical work whereby a student in a laboratory is engaged in a closed task with specially made apparatus. However, according to Millar *et al.* (1999) they all have a common feature, which is, linking the domain of ideas to the domain of real objects and observable things. What can be deduced from Millar *et al.* (1999)'s perception of practical work is that, it can be an open-ended investigation where students devise their own strategies, and closed exercises in which they (students) follow a certain set of instructions.

From the above descriptions one may deduce that practical work need not comprise activities at the laboratory bench nor, hands-on activities only. This finds support in Tomlinson (1979) where he argues that practical work can take many forms including those that engage the mind. Although Millar *et al.*(1999)'s description of practical work is more comprehensive other people may have different opinions in as far as practical work is concerned. These opinions many differ from Millar *et al.* (1999)'s. For example, some authors argue that there are other legitimate activities such as, computer-based activities; interviewing; debate and role play; writing instruments of various kinds; making models, posters and scrapbooks; library based research (Hodson, 1993) and concept mappings (Kapteijn, 1988) that they consider as practical work.

Although there are varying degrees of practical work, the bottom line is that learners should be actively involved and this should not be limited to manual or manipulative skills (Carin and Sund, 1980).

2.1.2 Types of practical work and related aspects

Although a number of classification schemes have been published in the science education literature for analysing types of interactions in the science teaching laboratory (e.g. Hofstein and Lunetta, 1991), there have been very few attempts to develop a classification system for science laboratory tasks themselves although some categories are well established, such as teacher demonstrations and student practical work (Millar *et al,* 1999). Woolnough and Allsop (1985) proposed a general classification of practical tasks into four groups: exercises, experiences, investigations, and illustrations of theory. As it has already be described in the previous paragraph, Millar *et al.* (1999) give an explicit and more comprehensive way of showing the different types of practical work.

Though research has failed to resolve the question of which approaches result in better learning (Clackson and Wright, 1992), it cannot be denied that teacher demonstrations saved time and required fewer specialised facilities (Hodson,1993). However, in research into the effectiveness of traditional laboratory work (Clackson and Wright, 1992), it was found that individual laboratory work was more effective at imparting simple manipulatory skills, measuring techniques, and knowledge of apparatus. In a later study, the investigation was extended to include classes which had no contact with the laboratory at all, either by individual experimentation or through demonstration. It was discovered that in written and practical tests dealing with laboratory work, the class with experience of individual work performed better than the class to whom experiments had been demonstrated.

Although individual laboratory work seems to be more effective at imparting simple manipulatory skills, measuring techniques, and knowledge of apparatus, it is not a favourable option for most schools in the third world countries because of the claim that there is lack of laboratory equipment. On the other hand, Manana (1994:p.254) argues that there is a range of ways of providing resources and equipment for practical science which include "improvisation by teachers in schools, in-service workshops for equipment and imported equipment." He continues by saying that in a fully articulated system, all four elements will contribute to the provision of appropriate resources matching the needs of practical science in the curriculum.

The issue of lack of apparatus should not be a problem as there are ways and means of dealing with the problem. The crucial issue here is getting science teachers motivated so that they can deal with the situation willingly and with dedication, for example, by improvising. Bennett and O'Neale (1998:p.58) assert that with the decreasing resources available for teaching this issue can be only be address by "ensuring that maximum benefit is obtained from laboratory work, and this means being quite clear about our objectives." From this perspective, knowing the objectives of doing practical work would discourage doing practical work for the sake of doing it hence squandering limited resources for nothing.

There are many other problems that cause a decline in the extent of practical work and the standards achieved such as academic and technical staffing (Bennett and O'Neale, 1998) and teacher confidence in handling practical work. The issue of teacher confidence may be solved by exposing teachers in in-service programs (Manana, 1994).

As it has already been mentioned, there are various types of practical work. Due to the scope of this study and the information gathered during the study, these activities will be limited to two broad categories namely: teacher demonstrations and student practical work.

2.1.2.1 Teacher demonstrations

Since the mid-nineteenth century when practical work achieved prominence (Layton, 1990) teacher demonstrations have been more widespread than individual experimentation by students.

The generally poor laboratory facilities and consequent organisational difficulties led teachers to abandon individual laboratory work in favour of teacher demonstrations since they saved time and required fewer specialised facilities (Hodson, 1993).

With teacher demonstrations, the teacher may assume all the responsibilities when performing practical activities, that is, not to ask for any kind of assistance from the learners, or the teacher may require some assistance from a few learners. According to research, teacher demonstrations in most cases can assist in re-inforcing theoretical work done in the classroom. In this method learners are relatively passive. All they do is to record what they observe (Hodson, 1993) , some may not be watching, especially when the demonstration is not drawing their attention. The use of worksheets for learners to write in their observations could encourage them to focus on what is happening.

Teacher demonstrations are believed to be just as suitable as are student-based 'hands-on' experiences for familiarising students with scientific phenomena and events, and may be more effective than student-based practical work in as far as an educational point of view is concerned (Kempa, 1988). This means that students can gain much from watching a skilled practitioner handling apparatus expertly and who involves them (students) in the process when an experiment is too dangerous, or complex.

2.1.2.2 Student practical work

Depending on the availability of material resources and the willingness of teachers, learners may work individually, or in groups. The teacher in some cases may demonstrate first, and then let the learners do an activity on their own. Alternatively, the teacher may give learners laboratory manuals or worksheets for guidance, and may provide assistance when required.

According to Millar *et al.* (1999:p.33) practical work carried by students themselves "usually working in small groups, is a prominent feature of school science education in many countries." Student practical work allows students to take responsibility in performing practical activities which in most cases are of the recipe-type where learners already know what to expect from the activities. Hodson (1993:p.99) is also of the opinion that "practical work commonly takes place in groups and, even when class directions are given, the experiences of individuals in different groups may vary substantially." Group work has its own weaknesses such that achievement in a group does not ensure internalisation of this learning by all its members (Klainin, 1984 in Klainin, 1988).

It really does not matter what type of practical work is done in schools as long as students are actively involved in them. What is important is for students to have practical experience. The reasons for this are outlined in section 2.2.

In the current study, for students to have done practical work they must have been involved in practical activities, either in the form of individual or group work, or at least teacher demonstrations. What is important is that they should be actively involved in hands-on activities. They must know the use of standard laboratory apparatus, not from books but having seen and used them.

2.2 The importance and aims of practical work

Practical experience is essential in the learning of science as it has always been an essential part of learning chemistry as chemistry is a practical science. This finds support in Davidowitz *et al.* (2000) who argue that data collection, presentation and interpretations are an essential part of the laboratory exercise. As important as laboratory experience is thought to be, there has been little systematic analysis of just what can be achieved in the science laboratory (Nersessian, 1989 in Hodson, 1993).

There are long standing arguments in favour of practicals. These include the acquisition of cognitive and manipulative skills, acquisition of an academic attitude to working, gaining of practical experience of phenomena (Steyn, du Toit and Lachmann, 1999) and the only way of experiencing at first hand many of the phenomena and events that science addresses (Hodson, 1993). It is clear that it is not enough to read about magnesium burning with a brilliant white flame or about light bending as it passes through a prism, one has to see these things happening and also take part in the doing of experiments.

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According to Novak (1976:p.495) new knowledge in science is constructed by means of experiments. He asserts that leading philosophers of science maintain that "experiments and observation are the core of the scientific enterprise......" Hence students need to develop practical skills in order to perform experiments and have further insight into the nature of science.

It is said that scientists are involved in developing an adequate and self-consistent system of concepts with which to understand the world as revealed in the results of experiments done (Harre,1972). According to Harre (1972) "...[science] is the building of a picture of the world." He continues by saying that what makes science different from other disciplines like Arts is the fact that "it is done under the discipline of the experimental method." This means that in science once a hypothesis is made it has to be proved experimentally. Chalmers (1982:p.1) furthers Harre's point, by asserting that "science is based on what we can see and hear and touch."

The importance of experimentation also finds emphasis in D'Abro (1951) where he cites an important example in the application of experiment in real life situation, "It ... enables us to match in the laboratory the spectral lines observed in the spectra of the stars and thereby to establish their significance." This explains why practical experience is very important in science. Furthermore, to show the importance of experimentation, if one looks back at the history of science, one would realise that the majority of empirical laws in science were obtained by the application of experimental method, for example, Boyle's law for gases and Des Cartes' law of refraction are empirical laws derived from experiment (D'Abro, 1951).

As a result of the recognition and acceptance of experimentation as being central to science and an integral part in learning science (Dechsri *et al.* 1997), science courses - including chemistry - in most universities, usually involve laboratory based components (Buffler *et al.*, 1998). This is also true of the University of the Witwatersrand (Wits). The first year laboratory activities are still conducted along traditional lines. Students work individually on their activities, which are largely prescriptive ('cook book' approach) and not open-ended investigations. A laboratory demonstrator (in chemistry) is available for some assistance and clarification, otherwise students are on their own.

These activities are scheduled every fortnight and run for three hours. However, it should be noted that in the design of these university laboratory activities it is necessary to take into account students' prior practical experiences. As Clackson and Wright (1992:p.40) state 'real' scientific research "does not proceed inductively, purely on the basis of empirical observation, but develops within a framework of previous knowledge and experience." Hence previous practical experience is very important as far as practical work is concerned.

If practical work is done or is to involve learning there should be reasons, aims or goals for doing it, as Naik (1996:p.50) argues that "the role of practical work has to be seriously considered if it is to be integral part of science curriculum." Knowing the purpose of doing practical work is motivation by itself, especially if it contributes in the learning of students. It is therefore important for students, and imperative to the teacher to be aware of the goals of practical work. The teacher should be able to design appropriate teaching strategies in order to achieve such goals because the best curriculum materials can result in limited student growth if a teacher is insensitive to the intended goals, to student needs and to appropriate teaching strategies (Hofstein, 1987).

It is therefore advisable that science teachers as well as their students are aware of the importance and objectives of practical work. If this is not done both the teachers and students may end up doing meaningless activities. In addition to the above, it is also important to consider seriously the way practical work is done at high school level. Practical work should be done in such a way that it motivates students as this might influence them into having interest in handling science subjects.

Hodson's (1993:p.33) view as informed by his twenty years of teaching and teacher-training experience is that practical work as conducted in many schools " is ill-conceived, confused and unproductive, it provides little of real educational value, and is counter-productive in terms of time and cost." The evidence suggesting the unproductive use of practical work by teachers in science teaching has led to the call for a radical reshaping of current practice based on the full understanding of the philosophical basis of science learning activities (Hodson, 1985).

It could be, as stated before, that some people are not aware of the aims of practical work. For some people doing practical work is like it is a tradition that they have to follow without finding out why (Woolnough, 1991). He goes further to state that science teaching is essentially a practical activity, with a long tradition of pupil experimental work in schools; yet, there are still large and fundamental questions about its most appropriate role, and the reality of what is actually achieved in a laboratory. Gabel (1999:p.549) also states that "a common component of chemistry instruction is the inclusion of practical or laboratory work." It is therefore necessary to look at the purpose of practical work in order to appreciate its importance.

The aims of practical work are so broad that some authors (e.g. Hodson, 1993) have decided to group them under sub-topics such as:

- manipulative skills
- attitude (e.g. interest)
- conceptual understanding
- processes of science

Other authors decided to adopt a different classification of the aims of practical work. Some practical aims seem to be difficult to classify. On the next page is a summary table of some aims of practical work cited by certain authors.

Table 2.1: A summary of some aims of practical work

AIM	DESCRIPTION
Teaching procedures of science	**To:** - be an integral part of the process of finding facts by investigation and arriving at principles (Hodson, 1993) - help distinguish between the immutable experiment facts of science from the more transitory theoretical explanations of the phenomena (Hodson, 1993 ; Johnstone & Wham, 1979) - be able to comprehend and carry out instructions (Beatty & Woolnough, 1982) - be an integral part of the process of finding facts by investigating and arriving at principles (Hodson, 1993 ; Johnstone & Wham, 1979) - promote simple, commonsense scientific methods of thought (Hodson, 1993) - appreciate the limits on results because of errors (Hodson, 1993 ; Johnstone & Wham, 1979) -develop skills in performing science investigations, analysing data, communication, problem-solving and creative thinking (Lunetta, 1988 ; Hodson, 1993 ; Tomlinson, 1979) - encourage accurate observation and description (Beatty & Woolnough, 1982) -develop students' understanding of the scientific approach to inquiry (Millar, 1999)
Supporting conceptual understanding	**To:** - promote intellectual development and conceptual understanding (Lunetta, 1988 ; Hofstein, 1988) - enhance the learning of scientific concepts increasing understanding of science and scientific methods (Lunetta, 1988) - elucidation of the theoretical work to aid comprehension (Hodson, 1993 ; Klainin, 1988), verify facts and principles already taught (Tomlinson, 1979 ; Hodson, 1993 ; Johnstone & Wham, 1979) - help students make links between the domain of objects and observable things and the domain of ideas (Millar, 1999) - test conceptual meaning (Novak, 1976) - develop concept meaning (Naik, 1996) - teach students concepts (Kapteijn, 1988)
Stimulating attitude and interest	**To:** - develop skills in working with others (Lunetta, 1988 ; Hodson, 1993 ; Johnstone & Wham, 1979) - arouse and maintain interest (Hodson, 1993 ; Tomlinson, 1977 ; Naik, 1996), attitude, satisfaction, open mindedness and curiosity in science (Hofstein, 1988) - develop self-reliance (Hodson, 1993 ; Johnstone & Wham, 1979 ; Denny & Chennell, 1986 ;Beatty & Woolnough, 1982). - indicate the industrial aspects of science (Tomlinson, 1979) - stimulate interest and enjoyment (Yager, 1991)
Examination purposes	**To:** - fit the requirements of practical examination regulations (Hodson, 1993; Tomlinson, 1979; Betty & Woolnough, 1982)
Relevance of experimentation	**To:** - make biological, chemical and physical phenomena more real through actual experiments (Tomlinson, 1977 ; Hodson, 1993 ; Naik, 1996).
Enhancing manipulative skills	**To:** - develop manipulative skills (Hodson, 1993 ; Tomlinson, 1979 ; Betty & Woolnough, 1982). - develop practical abilities (Hodson, 1993 ; Johnstone & Wham, 1979).

2.3 Some views against practical work

Although there is an outcry for engagement in practical work, there are also contrary views and some factors that hinder it. Since practicals are expensive and time intensive (Johnstone, Sleet and Vianna, 1994; Millar *et al.*, 1999), and as alternative ways of achieving instructional goals have become available, educators are again questioning the effectiveness and efficiency of traditional laboratory work (Steyn *et al.*, 1999).

There is an argument that practical work can be a means of developing laboratory skills that are believed to be transferable to other areas of study and to be of value to all children as an approach to confronting everyday problems outside the laboratory (Millar, 1993). This argument may not be valid in some situations because it could be difficult to associate the use of some of the laboratory apparatus with everyday life. For example, when and how would a learner use the skill of pipetting in everyday life?

Again one may question the validity of the argument made above which claims that practical work can be a means of developing laboratory skills. It all depends on how practical work is handled at individual schools. The common practice is that students follow instructions while carrying out an experiment and learn the skills by 'doing' rather than by being taught them (Meester and Maskill, 1995).

The use of computer-aided learning is becoming popular. According to Hodson (1993:p.112) computer-based activities "may often be superior to conventional bench work at bringing about concept development." and for the fact that there are many experiments that are too difficult, too expensive, too time consuming or too dangerous to carry out in any other way. But computers may be too expensive to get for every student, even more expensive that laboratory apparatus, unless they share.

Practical work may be limited in achieving its objectives. Kempa (1988:p.150) argues "to pretend that anything and everything is achievable through practical work is as foolish as it is naive." He further points out that "maintenance of this kind of argument will certainly not enhance our credibility in the eyes of those who consider practical work in science to be unduly expensive and time-consuming."

Woolnough and Allsop (1985) assert that teaching theory through practical work is not an efficient way of transmitting an understanding of scientific concepts to students. But according to some authors the aims of practical work are to teach procedures of science, to support conceptual understanding (not to teach it) and to stimulate attitude and interest (see table 2.1)

As already mentioned, practical work has its limitations. So to rely solely on practical work to transmit an understanding of scientific concepts may not be a good idea. For example, Johnstone and Wham (1982) argue that "when it comes to measuring the amount of learning taking place during practical work, the picture is rather pessimistic." It all comes to what the teacher wants to achieve out of practical activities.

To conclude this section, one would suggest that practical activities should be done with certain objectives to achieve. One should also bear in mind that not all objectives may be achieved through practical work. Again, for practical activities to be effective and educational, educators need to maintain the interest and enthusiasm of the students (Tomlinson , 1998)

The arguments against practical work should not discourage curriculum developers and educators from including practical work when planning the curriculum but should look critically into this issue. Practical work, as mentioned earlier, is an important part of science.

The importance of having practical experience is emphasized by Rollnick et al. (2000) and Gabel (1999) who argue that laboratory experience impacts on conceptual and procedural understanding. Gabel (1999:p.549) is of the opinion that helping students relate the three levels of representing matter (macro, sub-micro and symbolic) has potential for improving conceptual understanding, "an opportunity for doing this is through work in the laboratory." It should be noted that students' adequate preparation for the laboratory activities is crucial if conceptual benefit is to be obtained from practical experience (Rollnick et al., 2000). This means that if students have sufficient practical experience, they stand a better position of understanding the concepts involved in the sciences, as well as having a sound knowledge of following instructions involved in practical activities. There is an aspect of science that cannot be understood without hands-on practical work.

Hodson (1993:p.111) argues that in conducting scientific investigations " the development of conceptual knowledge and procedural knowledge proceed together........." This implies that practical experience impacts on procedural understanding.

2.4 Procedural understanding

It is very important that students have practical experience as Gott and Murphy (1987) suggested that science is about the solving of problems in everyday and scientific situations. To investigate and solve any problem, be it practical or not, there are a set of procedures which must be understood and used appropriately (Gott and Mashiter 1994). This set of procedures are sometimes referred to as practical skills. An understanding of how to put these skills together via the identification and operationalisation of variables and the display and the interpretation of data is what is called procedural understanding (DES,1989). For students to apply procedural understanding with confidence they must have considerable practice before (Gott and Mashiter,1994).

Procedural understanding according to Almekinders, Thijs and Lubben, (1997), "is the understanding of methods and procedures of practical enquiry used in science." while conceptual understanding is "concerned with facts, laws and theories about the natural world." In more simpler terms procedural understanding includes collection, manipulation and interpretation of experimental data (Davidowitz *et al.* in press). This implies that having practical experience impacts on one's procedural understanding. Thus practical work is important for promoting procedural understanding.

Millar *et al.* (1994) developed the idea of procedural understanding in more detail. They subdivide procedural knowledge, related to practical experience, into three categories. The first is manipulative skills, which includes knowledge of the use of instruments and the ability to carry out standard procedures (these skills are learned and improved through drill and practice).

Knowledge of the use of instruments and whether students have actually used them is the kind of practical experience that this study is attempting to ascertain. The second category refers to understanding of the nature and purpose of a scientific investigation. The last one, according to Millar *et al.* (1994) is understanding of evidence which refers to " the understanding of criteria for assessing and evaluating the quality of empirical evidence." This includes issues such as the decision to repeat a measurement and is influenced by an understanding of the concept of reliability.

2.5 State of practical work in South African schools

Some science educators and researchers are very concerned about the state of science practical activities at high school level. Naik is also of the opinion that in reality, very little laboratory or practical work (either as individual work, group work or teacher demonstrations) is done at high school level in most schools in South Africa (Naik, 1996). At the high school level questions have been posed about the efficacy of laboratory work leading to suggestions for the complete abandonment of practical work (Rollnick et al, in press) as a "costly sham" (Kahn, 1990 in Rollnick et al, in press).

Numerous reasons are given for the lack of practical work at high school level: insufficient provision of laboratories; lack of services (gas, electricity and water); lack of equipment and apparatus Bot (1997); large class size; time-table constraints; lengthy syllabus and shortage of qualified teachers (Bot, 1997 and Naik, 1996). The way students process new information is affected by the setting in which they learn (Gabel, 1999).

Another factor could be that there is no compulsion from the educational authorities on the teachers to do practical work. Some teachers may decline to do practical work under the pretext that it is not included in the final year assessment. To add to the factors that influence teachers not to do practical work, Naik (1996:p.49) states that there are some educators who "doubt the educational value of practical work whereas others argue against the way in which practical work is implemented and assessed." All these leave teachers in a state of confusion as to whether there is any need to do practical work at high school level. As a result, practical work is neglected.

Naik, (1996:p.49) claims that laboratory-based secondary school science teaching in South African schools has a strong support from science educators and various education departments. He goes on to say that "even the preamble to the physical science syllabus explicitly states the importance of laboratory-based science teaching." Teachers are, in fact, encouraged to carry out practical work whenever and wherever possible (Naik,1996). The main question, which will be answered later in this report is, do they actually perform these practical activities or not? If they are not done, what could be the problem(s)?

Curriculum developers and education departments may encourage teachers to do practical work and have that included in curriculum, but may not be implemented in schools. In most cases in the teaching and learning sphere, intended curriculum is not what is practised in schools because of certain problems which may include insufficient supply of resources (Taylor and Vinjevold, 1999).

According to research, the issue of science practical activities at high school level is not seriously considered, and hence students encounter difficulties when they get to university. Buffler *et al.*(1998) are of the opinion that the disjuncture between formal application and understanding "has possible implications for the effectiveness of practical work at university level in South Africa, particularly in view of the exposure to laboratory work.........." They argue that a large number of students who come from educationally disadvantaged sectors of the schooling system are "likely to encounter practical work for the first time on entering the laboratory at university."

Rollnick *et al.* (in press) are also of the same opinion about educationally disadvantaged students, and continue by saying that these type of students are also likely to be second language speakers of English, hence the emphasis on language skills and clarity in the laboratory manual are of prime concern. Therefore, such circumstances make it imperative to document procedural understanding and practical experience of incoming undergraduate students in South Africa so that appropriate teaching strategies can be designed.

The issue of first year students having problems when dealing with practical work at university does not happen in South Africa only. Research reveals that in the United Kingdom some first year students also encounter problems such as locating chemicals, understanding written instructions, carrying out techniques and procedures, and calculations required in laboratory practicals (Johnstone, Sleet and Vianna, 1994) cited by (Kaunda and Ball, 1998). This finds support in Bennett and O'Neale (1998:p.59) who assert that "the first year student enters the laboratory cold except for perhaps a short discourse on 'safety rules'."

When new information is linked to information that is already stored in the long-term memory of a learner more effective learning occurs (Gabel, 1999). Hence, establishing students' prior practical experience is very important for the teacher to facilitate meaningful practical work to the students.

Research was done at the University of Cape Town on pre-first year university students on how their laboratory experience at school impacts on their procedural understanding. The research instrument comprised of written probes to be used to explore the students' ideas regarding the reliability of experimental data, in particular the need for repeating measurements and the implications of the spread associated with data.

The study relates the patterns of reasoning of the students to their laboratory experience at high school (Buffler *et al.*, 1998). Furthermore, it reveals that students in the sample had different perceptions on repeating measurements. Some students did not find the need to repeat measurements while others believed that three or several measurements were necessary. Data collected shows that the majority of students agreed on the need for repeats (Buffler *et al.*, 1998).

From the responses gathered, it was discovered that the spread associated with data collection is not appreciated and that calculating the mean is largely a rote response. Hence that is why in the study by Buffler et al. (1998) students with more laboratory experience were found to be more aware of the possibility of outlying data points and therefore exercised judgment rather than routine. The researchers argue that the study relates some aspects of the students' procedural understanding to their prior experience of school laboratory work (Buffer *et al.*, 1998).

From the data collected, the researchers argue that it would be reasonable to expect that the responses are related to the level of experience with practical work at school as they contend that laboratory experience influences the response patterns. According to Buffler et al.(1998) practical work impacts on procedural understanding.

Rollnick et al.(in press) argue that background knowledge in the form of conceptual and procedural understanding acts as a filter to the understanding of the events and actions which face learners in the laboratory. This implies that those students with poor background knowledge will encounter a lot of problems when dealing with laboratory activities.

It is therefore appropriate to establish students' practical experiences before they are engaged in university practical work. The use of valid instruments in determining students' practical experience is very crucial as well as valid responses from respondents.

2.6 The need for validity

The aim of this study, as mentioned in chapter one, is to validate instruments used to establish chemistry practical experience of high school students. These instruments have never been validated before. The use of valid research instruments is of great impc-tance and is imperative, as Sanders and Banda (1997:p.12) assert that researchers must be able to claim with confidence that their data-gathering tools and techniques "measure what they purport to measure, and that their research provides an authentic interpretation of reality." This finds support in Buffler *et al.* (2000:p.2) who cite (McGinn and Roth, 1999) that " for knowledge claim to pass from the personal domain to the realm of shared scientific knowledge, the quality of the claim, that is, the reliability and validity of the consolidated result, has to be communicated."

Validity is not a property of a test or assessment as such, but rather of the meaning of the test scores which are a function not only of the items or stimulus conditions, but also of the persons responding as well as the context of the assessment (Messick, 1995). This means that, in particular what needs to be valid is the meaning or the interpretation of the score, as well as any implications for action that this meaning entails (Cronbach, 1971) cited by (Messick, 1995). Therefore, without the assurance of researchers that their research provides an authentic interpretation of reality, it is pointless to use instruments or do an investigation because any conclusion reached or claims based on the research would be meaningless (Sanders and Mokuku, 1994).

Validity is therefore, a crucial issue in educational research as far as research is concerned. Whatever educational researchers come up with, in their research and is published, will definitely impact on school curriculum. This will be the case where the research has to do with the education of children. Sanders and Banda (1997:p.12) argue that classroom practitioners "rely on educational researchers to find more effective methods of teaching and learning science subjects." It is therefore vital that researchers report back reliable and valid information to the society.

The validation of instruments used in establishing practical experience in high school chemistry is crucial as this will assist very much in the restructuring of school science curriculum. However, research data are only valid if they provide a measure of what is intended to measure, in this case students' experience of chemistry practical work. However, the format of the instrument may influence the validity of the data collected (Lubben *et al.*, 2000). Hence research instruments need to be re-checked each and every time they are used. Sometimes the data collection instrument, at face value, may seem to be perfect but, if responses are not reliable then, the validity of the data is questionable. Validity, therefore may not depend on data collection instrument only but, also on the responses of participants.

In this study the respondents are students and teachers. The question is, are the teachers and students' responses reliable? Reliability of responses is a prerequisite for validity (Sanders and Banda, 1997). This implies that validity and reliability are not absolute values attached to a research instrument (Sanders and Banda, 1997), nor is validity a commodity that can be purchased with techniques (Brinberg and McGrath, 1985). What then is validity?

Messick (1989b) cited by (Messick, 1995:p.741) defines validity as "an overall evaluative judgement of the degree to which empirical evidence and theoretical rationales support the adequacy and appropriateness of interpretations and actions on the basis of test scores or other modes of assessment." Though the principles of validity apply to interpretive and action inferences derived from test scores, it also apply to inferences based on any means of observing or documenting consistent behaviours or attributes.

The term "score" is used generally in its broadest sense to mean any coding or summarization of observed consistencies or performance regularities on a test, questionnaire, observation procedure or other assessment devices (Messick, 1995).

In simpler terms validity is like integrity, character, or quality, to be assessed relative to purposes and circumstances (Brinberg and McGrath, 1985).

Sanders and Mokuku (1994) cite four important points on validity to be noted by researchers. These are as follows:

- validity refers to the results of a test, and not to the test itself (Gronlund, 1976)[although problems with a test can certainly affect the results]
- a test can be valid in one situation yet lack validity in another (Schumacher and McMillan, 1993)
- validity is not an absolute value which can be calculated. It is an ideal state to be pursued, but not to be attained; it is like character, or quality, to be assessed relative to purpose and circumstances (Brinberg and McGrath, 1985)
- it must be remembered that the validity of research has several components. It is therefore important to look not only at the validity of the results obtained by the data-gathering tool, but at the validity of the inferences made by the researcher (Schumacher and McMillan, 1993)

Validity can be divided into various types. Among the various types, one finds in modern social science convergence, correspondence, differentiation, equivalence, generality and repeatability (Brinberg and McGrath, 1985). There is also the positivist research tradition which looks at something that is already established in a way of proving or confirming it. According to this tradition, validity is divided into three types namely: content validity, criterion validity and construct validity.

Content validity is "the systematic examination of the test content to determine whether it covers a representative sample of the behaviour domain to be tested" (Anastasi, 1968). This means that it is concerned with the completeness with which the data cover the area being explored. Checking content validity is not an easy task as pointed out by Anastasi. It requires a strictly accurate systematic checking. It also could check on abilities, skills or content knowledge , for instance but, not personality or aptitude tests. In most cases, content validity is established by consulting experts and should not be confused with face validity which is (face validity) based on validity checks by experts, often purports to guarantee content validity (Sanders and Mokuku, 1994). In the case of experts establishing content validity for example, a systematic check on test has to be done to find out whether the curricular content has been thoroughly covered (Anastasi, 1968).

For the purposes of the current study, content validity may apply to students' familiarity with basic laboratory apparatus, that is: (i) the ability to identify and give uses of the apparatus, and (ii) the experience they have with 'hands-on' activities. With 'hands-on' activities, the researcher focuses on whether the activities had individual, group or teacher demonstrations.

Criterion validity looks at the appropriateness of the chosen external criterion (Oppenheim, 1992) in the data as an indicator of what is to be measured. For practical experience, Lubben *et al.*(2000:p.88) argue that "such criteria could vary from the use of students' demonstrated experimental skills, their ability to design investigations or write practical reports, the percentage time scheduled for practical work in teachers' lesson plans.." as criteria.

Construct validity is reported as having to do with the extent to which the data measure a theoretical construct (Anastasi,1968, and, Lubben *et al.*,2000) or an attribute assumed to be reflected in the data (Lubben *et al.*, 2000). The latter description includes knowledge of science concepts and experiences which in this study could be the way in which practical experience is perceived and how appropriately this could be reflected in the data.

However, Messick (1995:p.741) claims that the idea of dividing validity into three types mentioned above, is "fragmented and incomplete, especially because it fails to take into account both evidence of the value implications of score meaning as a basis for action and the social consequences of score use."

In this study the positivist research tradition, whereby validity is divided into three types namely, content validity, criterion validity and construct validity will be used. When validity is divided into its components it is easier to figure out which one is being compromised in a data collecting instrument. This makes amendments to the instrument much easier.

2.7 Ways of measuring experience of practical work

When assessing students' experience of school practical work, a balance has to be struck between the demand for highly valid data and the ease with which to collect these data (Lubben *et al.*, 2000).

Students' experience of practical work can be easily obtained through impressionistic observations or encounters. For example, by surveying the laboratories, store rooms or preparation rooms. Also when talking informally to the teachers and students one might get different account with the teachers in most cases trying to portray a better picture of their schools while students usually give negative reports about their schools and teachers.

Lubben *et al.*(2000) assert that at "university level, the frequency of technicians' stories about students who do not know how to hold a thermometer, or how to connect an ammeter, is a similar anecdotal evidence of previous experimental experience in physics." However, the easy but unsystematic way of collecting such data results in a low content validity, a questionable criterion validity and a low construct validity. More systematic methods of collecting valid data on students' practical experience can be used. For example, a closer look at how the curriculum caters for practical work. The intended curriculum can be prescribed in details, practical work included, but the delivered curriculum may vary widely between schools in the same country (Taylor and Vinjevold, 1999).

Other options could be collecting data through class observations or compiling lesson plans, or checking students' practical exercise books (if they have any). However, these options may prove to be time consuming or unrealistic (rarely is a complete set of lesson plans accessible, and performance assessment of practical skills is, generally, not part of the curriculum) in many Southern African situations (Lubben *et al.,* 2000).

Another way of collecting data on students' practical experience, which brings us closer to the method used in this study, is from incoming students to find out the type and amount of practical work they have done. Ka ıda and Ball (1998) and Buffler *et al.* (1998) used this method and the data they collected depended on students' responses. As mentioned earlier, some students may try to impress the researcher and thereby giving a false impression of the actual situation.

Rollnick *et al.*(1999) also gathered information from incoming students to measure their level of practical experience. Their instrument claims to determine the level of practical experience through what students remember of certain pieces of laboratory apparatus and their uses. Students are asked to name 10 pieces of laboratory apparatus, say whether they have used them, and give their uses. This is the instrument, together with two more, that is to be validated in this study.

This study tries to validate the instrument by Rollnick *et al.* (1999) which is the primary instrument in this study together with the other two instruments. Details about the three instruments and how they are going to be validated will be discussed in the next chapter under methodology.

It should be noted that the kind of practical work that this study looks at does not include other forms of practical experiences such as: activities that make use of representations of real objects or materials, such as computer simulations or video recordings (Meester and Maskill, 1995; and Millar *et al.,* 1999). Other examples, as Lubben et al. (2000:p.89) argue could include "visits [of students] to science exploratoria, descriptions of experiments in textbooks or films, or indeed any combination of these." The study also did not cover micro-scale equipment.

2.8 Directions from the literature review

The literature revealed that some researchers are very concerned about the state of science practical activities at high school and are of the opinion that very little practical work is done (Naik, 1996). Several reasons are stated in the literature such as: (1) lack of laboratories and laboratory equiment (Millar *et al.,* 1999 and Naik, 1996), and huge numbers of learners per class (Klainin, 1988) ; and (2) academic and technical staffing (Bennett and O'Neale, 1998). Hence that is why in the present study four schools from three different historical communities - White, Indian and Black were selected in order to capture a variety of experiences across the diverse schools in South Africa (see section 3.1 chapter 3).

The literature also reveals the advantages and disadvantages of practical work as viewed by some researchers. There is this idea that practical work in the form of individual activities helps students in their class practical or written tests dealing with practical work (see Clackson and Wright, 1992). Some researchers (e.g. Hodson, 1993) also claim that engaging in practical work assist students in acquiring manipulative skills, measuring techniques and knowledge of apparatus. However, other researchers argue that practical work is time consuming (Johnstone, Sleet and Vianna, 1994), and may require specialised facilities (Hodson, 1993) which could be very expensive (Johnstone *et al.,* 1994).

Despite the short-comings, practical work is essential in science. It motivates and encourages students to engage into science-based subjects areas like medicine, engineering and others. Practical work can be made less expensive by using easily available materials. For example, teachers may improvise or use other types of practical activities besides going to the laboratory. There are activities like computer simulations, using video tapes, micro-scale equipment and others.

The literature also revealed that the issue of validity is of great importance and the use of valid instruments is crucial as researchers must be able to claim with confidence that their data-collecting instruments measure what they purport to measure (Sanders and Banda, 1997). Also the use of more than one data collecting instrument is encouraged for validity purposes (Cohen and Manion, 1994). It is important to note that validity does not depend on the data collection instrument but also on the data themselves (Lubben *et al.*, 2000). This implies that a researcher has to be very careful when designing a data collection instrument and it is important that the instrument is piloted to allow changes before it is used in the actual investigation. Also the kind of data collected should be relevant to the study.

In the present study all the data collection instruments (questionnaire and interview schedules) were piloted as characterised in section 3.6 in chapter 3. Some data collection instruments may seem to be perfect at face value but, if responses are not reliable then, the validity of the data is questionable. Validity, therefore may not depend on data collection instrument only, but on the responses of participants.

In conclusion, the researcher found some important methodology aspects that helped in the shaping of the current study. The aspect of validity played a very important role in the shaping of the study such that the researcher had to use more than one instrument to claim validity. This led to a careful selection of questions for interview schedules. Having selected the questions, the researcher piloted them. The issue of piloting also played an important part in the shaping of the study.

CHAPTER 3

RESEARCH METHODS AND COLLECTION OF DATA

3.0 Introduction

This chapter gives an account of how the research was carried out, including the mode of data collection. This includes choosing the sample(s), contacting the schools, problems encountered, implementation, design and instruments, piloting of the instruments, and finally, concluding remarks.

3.1 Choosing the sample

Since this study is based on the practical experience of high school chemistry students, it follows that Grade 12 physical science students were preferred for this study. Grade 12 students were chosen on the assumption that at this stage one can get a clear reflection of practical work they have done, and also for the fact that they are closest to the population (incoming university chemistry students) used previously in the same kind of study. To capture a variety of experiences across the diverse schools in South Africa, schools were selected from three different historical communities - White, Indian and Black. The Indian sample was of particular interest as in the former dispensation, Indian schools ran practical examinations in matric.

The selection of participating schools was done in such a way that one former white, one former Indian and two former Black schools were chosen. The former Black schools were considered likely to be poorly equipped and having less qualified staff. The researcher wanted to find out whether the difference (if there is any) in educational backgrounds (advantaged and disadvantaged schools) could have an effect on their practical experience. There were 98 students who participated in this study.

The size of the sample may look small but is a convenience sample. It is not meant to be representative but to validate the instruments. Convenience sampling, as Cohen and Manion (1994:p.88) put it, involves "choosing the nearest individuals to serve as respondents......"

Pupils and student teachers often serve as respondents in surveys based upon convenience sampling (Cohen and Manion, 1994).

Rural schools were not included in the study for two important reasons: - time constraints and limited budget. The researcher was aware of the possibility that data from these schools could have portrayed a different picture - as far as practical work is concerned - because of poor material resources such as laboratories, laboratory equipment and so on. Shortage of human resources such as suitably qualified teachers could also contribute.

Table 3.1 shows the type and locations of schools that participated and the number of students involved per school in this study. The names used are fictitious.

Table 3.1 Types of schools and students who participated

Name of school	**Area**	**Type of school**	**Number of students**
Highlands	Town	Former White school	24
Sefika	Township	Former Black school	27
Abdool Moosa	Township	Former Indian school	32
Matsieng	Township	Former Black school	15

3.1.1 Contacting the schools

The researcher was introduced to a number of schools that would be willing to help by allowing him on their premises to work with the students. Four schools (as shown in table 3.1 above) were selected namely: Abdool Moosa high school which is predominantly an Indian school, Matsieng high school and Sefika high school, both are former Black schools, and Highlands high school - a former White school. A lecturer at Wits who happened to be a former teacher at the Indian school introduced the researcher to the head teacher of that school. Thereafter, the researcher and the head teacher of the school communicated through the telephone and in person. The two former Black schools were recommended by a friend, and that made it easier for the researcher to hand post letters - asking for permission to carry out the study - to the head teachers. With the last school - a former White school - the researcher encountered it by chance.

The researcher, with a colleague were on their way back to where they stay after a disappointing encounter with another former 'White' school. One physical science teacher refused to allow the researcher to carry out his study with her students, the reason being that the students were busy with preparations for the matriculation examination. The same teacher had previously allowed the researcher's colleague to carry out his research with her students. So the colleague then decided to introduce the researcher to the teacher hoping that she would be willing but that was not the case. On their way back, the researcher and his colleague saw one school and decided to enter the school to try their luck. They were sent to the head teacher who gave them permission to see physical science teachers. Everything went fine. The teachers agreed to cooperate but pointed out that Grade 11 students are the only ones that are available not Grade 12 because they were preparing for their final examinations and were difficult to assemble. Because of students' preparations for the final examination, the researcher was aware that responses may have been rushed.

So, in all cases the researcher made contacts with the schools on telephone, through letters (see Appendix A) and personally, explained the research project and its purpose and was then given a go ahead by the principals of the concerned schools. The researcher was then sent to the heads of the department of science who further introduced the researcher to the senior physical science teachers to obtain agreement from them (teachers) and pupils. The researcher briefly explained the purpose of his research to the physical science teachers and the pupils and made it clear that their participation was on a voluntary basis. To the pupils, the researcher also made it clear that they were not going to be assessed on whatever came out of the research.

A brief introduction of the research instruments (questionnaire and interviews) to the participants was done by the researcher who went on to explain that the type of questionnaire that was going to be used in the research (for pupils only) was a written type of questionnaire (see Appendix B). Those who were to be interviewed were advised that the interviews were going to be tape recorded. The researcher, together with the participating physical science teachers sat down and decided on the dates and times at which the investigation could be launched. The researcher went through the four schools setting up dates and coming up with a schedule that would suit all the participants.

3.1.2 Problems encountered

The time available to the researcher to launch the investigation coincided with the students' preparation for their final examinations. Fortunately, the physical science teachers were sympathetic enough to sacrifice slots in their tight schedules for the researcher to continue with the study. Unfortunately, though the teachers tried to help, one school experienced some difficulties in trying to assemble Grade 12 students because they were no longer in class. The students were studying on their own, so it was not easy to get hold of them. The researcher decided to use Grade 11 students as substitutes as these were close to move into Grade 12 and hence were suitable for the study. This happened at one school (Highlands) only.

Another problem that the researcher came across was that of some of the participants not doing things according to schedule. One teacher did not keep to the dates and time scheduled. The teacher was either absent from school or asked for a postponement. He was extremely difficult to contact. The researcher thought that may be the teacher was not comfortable with the whole arrangement but, on consulting with the deputy head teacher, the researcher learned that the teacher's evasiveness had nothing to do with the research but his usual behaviour of ignoring his obligations. However, the researcher finally succeeded in tracking down the teacher.

Another teacher was very uncomfortable with the idea that the interview session involving him and the researcher was going to be tape recorded. The researcher was aware of the fact that if participants were uncomfortable with tape recording he was not supposed to force them into it but, to abandon it and opt for writing down their responses to the interview. However, the researcher allayed the teacher's fears by ensuring him that the interview was strictly for research purposes and nothing else. The researcher also promised the concerned teacher that no real names will be mentioned in the report.

3.2 Implementation

On the day of implementation of the research study, the researcher was introduced to the students by one of the physical science teachers at each school. The teacher explained the purpose of the researcher's visit to the school, and the researcher in turn introduced himself, briefly introduced his research project to the students and asked them whether they would like to be part of the study before administering the questionnaire to them. The researcher also informed the students that subject to their agreement, four of them were going to be interviewed immediately thereafter.

The administration of the questionnaire was done by the researcher himself, as Gay (1981:p.159) puts it, "by so doing the researcher gets the opportunity to establish rapport with respondents, explains the purpose of the study , and clarify individual items." Immediately after the filling in of the questionnaire, four students were randomly chosen to participate in the interview session which was done thereafter. The researcher made sure that male and female students were equally represented in the interview session, that is, two male and two female students were chosen. The researcher thought that having information from both sexes would be helpful. Some research reveals that in Southern Africa girls are less enthusiastic to do practical work than boys (Dlamini *et al.*, 1996). Probably this is because boys take the initiative and girls either watch or write down results or observations that are made by boys. So it would be interesting to know their perceived and experienced practical experience as far as practical work is concerned. However, it should be noted that the issue of boys and girls is not explored in this study.

The interview sessions were done on a one to one basis, meaning that one student at a time was interviewed. Physical science teachers knew, already, that they were also going to be interviewed. Teachers' interviews were done at a later date. The researcher and the concerned teachers sat down and decided on convenient dates that would suit both to carry out the interviews. On the said dates interviews with two physical science teachers took place and went well. The whole procedure was carried out in all the four schools.

3.3 Design and instruments

3.3.1 Design

Data was collected in the form of a written questionnaire and interviews. The questionnaire was designed for students only, while the interview sessions were held for students as well as physical science teachers. Because of time constraints and delineation of the research project, not all students and physical science teachers were interviewed. Only four students and two physical science teachers from each school were interviewed. This implies that a total of 24 interview sessions was carried out.

3.3.1.1 The teachers

Two Grade 12 physical science teachers from each school participated in the investigation, making eight teachers altogether. Table 3.2 shows the number of teachers - from each school - who participated in the investigation, their experience (i.e. how long they have been teaching physical science at their respective schools), the grades they have taught so far and, the names of schools involved. This information was gleaned from the interviews (see Appendix D)

Table 3.2 Teachers' teaching experience and grades taught

Name of school	Physical science Teacher	Overall teaching experience	Grades taught
Highlands	Teacher 1 (TH1)	13 years	8, 9 and 10
	Teacher 2 (TH2)	6 years	10, 11 and 12
Sefika	Teacher 1 (TS1)	5 years	11 and 12
	Teacher 2 (TS2)	14 years	10, 11 and 12
Abdool Moosa	Teacher 1 (TA1)	6 years	8, 10, 11 and 12
	Teacher 2 (TA2)	4 years	11 and 12
Matsieng	Teacher 1 (TM1)	19 years	11 and 12
	Teacher 2 (TM2)	6 years	10 and 11

3.3.1.2 The students

As mentioned above, 98 Grade 11 and 12 students participated in this study for reasons already mentioned.

3.4 The instruments

A questionnaire (consisting of three existing instruments) and interviews were used in this investigation. The reason for using a questionnaire is because the purpose of this study is to validate a previously used questionnaire, used to establish practical experience of students. Hence the same questionnaire that was used before for the same purpose is used in this research. The interview sessions were used to validate the questionnaire. The reason for using more than one strategy of collecting data is that exclusive reliance on one method, as Cohen and Manion (1994:p.233) argue, "may bias or distort the researcher's picture of the particular slice of reality a researcher is investigating." Therefore, the use of the interview sessions was to cross check the students responses against what they said in the questionnaire. Both learners and teachers were interviewed. The reason for interviewing teachers as well was to check for consistency in both the teachers and students' responses.

3.4.1 The questionnaire

The questionnaire consisted of three instruments (Instrument 1, Instrument 2, Instrument 3) which had been used in the past to determine practical experience of incoming university students (see appendix B). The first instrument determined specific practical experience and was used by Rollnick *et al.* (1999). This is the primary instrument to be validated in this study. The second one determined general practical experience and was used by the Physics department at the University of Cape Town (Kaunda and Ball, 1998), and the third one was from the College of Science at the University of Witwatersrand in the early 1990's also determined specific practical experience. All three instruments had been piloted before, but were never validated. The purpose of the other two instruments was to help in the validation of the first instrument by Rollnick *et al.* (1999).

The three instruments were administered in a single questionnaire (instrument 1 to 3). In instrument 1, a diagrammatic representation of ten pieces of laboratory apparatus labelled A to J, was given to students. Students were supposed to name the 10 pieces of laboratory apparatus labelled A to J. After naming the 10 pieces, students were required to say what they had used each piece of apparatus for and were to leave the spaces provided blank in the answer sheet if they have not used the apparatus at all.

In instrument 2 students were to relate their practical work experience in physics, chemistry and biology, their school experience of practical work, and whether they thought laboratory work was an important part of physical science and biology. They were then required to give explanations to their answers. In instrument 3 students were given a list of laboratory apparatus and were asked to say whether they (themselves not the teacher) have used each of the given apparatus, whether they have seen the teacher use it or they have only seen a picture of the apparatus, or they have never seen it before.

There are advantages as well as disadvantages of using a questionnaire. Some advantages are such that it is more efficient in that it requires less time, is less expensive, and permits collection of data from a much larger sample (Gay, 1981; Fraenkel and Warren, 1990; and McMillan and Schumacher, 1993). Some disadvantages are that unclear or seemingly ambiguous questions cannot be clarified and the respondent has no chance to expand on, or react verbally to, a question of particular interest or importance (Fraenkel and Wallen, 1990). Hence that's why an interview was used as well to make up for the deficiencies of a questionnaire. Piloting, which will be described later, can also play an important role in overcoming some of these deficiencies .

3.4.3 The interviews

Bell (1987:p.70) alludes that a skillful interviewer can follow up ideas, "probe responses and investigate motives and feelings, which the questionnaire can never do." To add to what Bell (1987) says, McMillan and Schumacher (1993:p.250) also argue that an interview can be used with many different problems and types of persons, "such as those who are illiterate or too young to read and write, and responses can be probed, followed up, clarified, and elaborated to achieve specific accurate responses." In this way it is possible to obtain data which is less likely to be accessed in a written format (Trembath, 1984 in Sanders and Mokuku, 1994).

Interviews can also serve special purposes such as when dealing with children. Seddon *et al.* (1990) point out that "younger children are comparatively better able to comprehend and communicate in the spoken than the written word." Mokuku (1993) asserts that second-language scholars are likely to be able to explain their ideas more effectively in an interview situation than in writing, especially if they are allowed to use their mother-tongue.

However, there are many disadvantages as well, in using an interview. The primary disadvantages of an interview are its potential for subjectivity and bias (Gay, 1981 and McMillan and Schumacher, 1993), they are time-consuming to conduct (Bell, 1987 and Sanders and Mokuku, 1994), transcribe and analyse (Sanders and Mokuku, 1994). The presence of the researcher may inhibit respondents so that they do not say what they really think (Fraenkel and Wallen, 1990, Sanders and Mokuku, 1994).

The researcher was also aware that it is not easy to conduct interviews and that it requires experience to master. This skill can be acquired with a long period of practice. Posner and Gertzog (1982) relate why an interviewer needs to practise his/her interview skills over a long period of time:

> "Problems with interpretation (of interview transcripts), however, can be undeniably thorny. This is one of the primary reasons that nearly every experienced interviewer emphasises that interviewing skills can only be developed by conscious effort over an extended period of time."
> (Posner and Gertzog, 1982).

It is also important to train beginning interviewers as they need to have the basics in interviewing, like for instance: to establish rapport with their interviewees and put them at ease; to know when and how to "follow up" on an unusual answer or one that is ambiguous; to be aware of certain gestures, manner and facial expression - as a frown at the wrong time can discourage a respondent from even attempting to answer a question (Fraenkel and Wallen, 1990).

Because of the importance of developing interviewing skills, the researcher participated in a short course in which individual students who participated were video-taped conducting individual interviews while other participants were observing so that the latter could pick up weaknesses, mistakes, as well as strengths of the interview. The subsequent televised playback of the individual interviews allowed for discussion and constructive comments as well as for each interviewer to critically observe his/her interview technique. This exercise was very helpful though it was done only once. It could have been better if it was done more than once. At the time of launching the study, the researcher was at least familiar with what an interview is like.

As it has been mentioned before, the interviews were designed for both the teachers and students. The researcher interviewed physical science teachers from each school in order to cross-check the data that was gathered from the students. The interview sessions for both teachers and students were done on a one to one basis, that is, the interviewer dealt with one student at a time away from the others so that they (students) should not have the slightest opportunity of trying to copy responses from others. Both teacher and student interviews were tape-recorded. The subjects were informed before the study was carried out that there was going to be a tape recorder for interviews, and were asked whether they felt comfortable or not. The participants had no problem with the tape recorder.

The student interview was a structured type of interview which took approximately fifteen minutes per student. In a structured interview content and procedures are organised in advance (Cohen and Manion, 1994, and McMillan and Schumacher, 1993). This means that the sequence and wording of the questions are determined by means of a schedule and the interviewer is left some freedom to make modifications (Cohen and Manion, 1994). A structured interview is therefore characterised as being a closed situation. An unstructured interview, on the other hand, is said to be an open situation, having greater flexibility and freedom (Cohen and Manion, 1994). Teacher interviews were also of the structured type and they took approximately ten minutes per teacher. The researcher used structured interviews to stimulate and focus discussion.

A sample of sixteen students was interviewed, four from each school. The selection of these students was done on the basis of the responses (conflicting responses) that were generated from the questionnaires, though it was always random because of the time factor. The interview attempted to establish the following;

- which topics were covered in the experimental work
- Whether experimental work was done on an individual or group basis.
- Whether experimental work was demonstrated by the teacher.
- What apparatus was used.
- What type of experimental work was done, e.g. quantitative or qualitative.

The interview also included ten real pieces of laboratory apparatus which were exposed to the students for them to name them and say what they are used for. This is exactly what they did in Instrument 1 in the questionnaire except that in this case they were exposed to real apparatus and were doing the instrument verbally. This was done to check consistency in students' responses. After the interviews were transcribed, transcripts were taken back to the interviewees for them to confirm that what was on paper was exactly what they told the interviewer.

3.5 Development of interview schedules

The researcher drafted some interview questions for student and teacher interviews bearing in mind what kind of information he was looking for. After peer review, the researcher made a second draft of the interview questions which was finally approved by the peers (see Appendix C).

3.6 Piloting of instruments

Prior to the launching of this study some piloting was done. Formal evaluation of a research plan involves a pilot study, which is sort of a dress rehearsal (Gay, 1981), and in most cases it involves a smaller sample of individuals (Johnson, 1977). Its purpose is to detect any problems so that they can be remedied before the study is carried out (Fraenkel and Wallen, 1990). Regardless of the care with which items are constructed, there will be terms that are not well defined and statements that are unclear (Johnson, 1977). The researcher may not be able to anticipate the variety of interpretations among a diverse group of respondents. To overcome these problems a pilot study is advisable.

As a result of doing a pilot study, new researchers gain valuable experience and the quality of one's instrument may improve considerably. Even a small-scale pilot study, based on a small number of subjects, can help in refining procedures such as instrument administration (Gay, 1981).

3.6.1 Piloting the questionnaire

Ten first year students from the College of Science at the University of the Witwatersrand were asked to fill in the questionnaire. One of the reasons for piloting the questionnaire was for the researcher to establish average amount of time taken by the students in filling in the questionnaire. This was to give the schools involved an idea of how much time the researcher would need with their students. The researcher discovered a lot from the piloting process. It helped the researcher to prepare things better for the actual instrument. The next paragraph portrays what the researcher discovered after critically looking at the analysis of the piloting and the measures to be taken to come to terms with the problems encountered.

As it was mentioned before, the questionnaire was divided into three instruments, instruments 1, 2 and 3. Instruments 1 and 3 involved identification of laboratory apparatus. Some of the apparatus were common to both instruments. This potentially allowed respondents to refer back to either one for their responses. So the researcher decided to separate the two instruments in the actual research study. What the researcher planned to do was to use envelopes. Instrument 1 was to be put in one envelope and Instrument 2 and 3 in another envelope. The idea was to give out envelopes with Instrument 1 first and as soon as the respondents were through with it, then the other envelopes containing Instrument 2 and 3 were to be distributed to the respondents. On average, it took 40 minutes for the students to fill in the questionnaire.

3.6.2 Piloting the interviews

Two College of Science students, from the ten who filled in the questionnaire, were then engaged in an interview session to pilot the pupils' interview schedule. Two post graduate students (teachers by profession), doing their Masters in science in the School of Science Education at the University of the Witwatersrand , were engaged in the interview sessions to pilot the teachers' interview schedule. The purpose of piloting the interview schedules was two-fold. Firstly, it was to evaluate whether the interview questions which the researcher had developed for the study elicited the information required, and to make changes if necessary. Secondly, it was intended to provide the researcher with opportunity to develop further his interview techniques.

With the student interview, the first task for the respondents was to identify 10 pieces of laboratory apparatus exposed to them, and then say what they have used them and what they are used for. The respondents were not sure whether to touch the apparatus to take a closer look at them. The researcher did not tell the respondents that it was fine if they picked up the apparatus. After identifying one piece of apparatus, respondents would wait for the researcher to give them a go ahead instead of just continuing with the procedure.

Another observation made by the researcher was that respondents were uncomfortable when they approached a piece of apparatus that they did not know. From these observations the researcher decided to approach the interviews in such a way that the respondents participated freely. Respondents were assured of anonymity. There was nothing much as far as teachers' interview was concerned except that more probing was to be done in other to get more information.

In general, examination of the interview transcripts revealed that - the researcher should be aware of leading questions, and that during the interview sessions the researcher's task is to ask questions and listen to the responses not to pass comments or teach the respondents.

3.7 Concluding remarks

The pilot study greatly improved the researcher's approach to the study. Firstly, the way in which the questionnaire was administered changed after flaws were identified during the piloting. Secondly, the researcher's interview techniques improved considerably. The pilot study also provided useful insights about how to phrase the interview questions with more clarity; hence the collection of data generally went on smoothly. The next chapter looks at data analysis.

CHAPTER 4

DATA ANALYSIS

4.1 Introduction

This chapter looks at the analysis of the data collected from the students' questionnaire and interview sessions with students and teachers. As mentioned in chapter 3, there were three instruments in the questionnaire that was issued to the students. As has already been mentioned in chapter 3, data for the first instrument was on identification of 10 pieces of standard laboratory apparatus and their uses. In the second instrument students were to relate their practical experiences in as far as practical work is concerned. Instrument 3 was testing passive knowledge as students merely had to recognise names of equipment rather than recall uses.

A coding system was developed for each instrument to assist in the analysis of data collected. The coding system for instrument 1 has been adopted from Rollnick *et al.* (1999); for instruments 2 and 3 coding systems were developed on the basis of the coding system for instrument 1. Data collected from the interview sessions was coded using the same coding system adopted from Rollnick *et al.* (1999). First of all this chapter will try to explain explicitly, the coding systems used for the 3 instruments, followed by a step by step analysis of the data collected.

4.2 Instrument 1

Instrument 1 tested remembered laboratory experience.

4.2.1 Coding system for Instrument 1

The coding system for instrument 1 has been adopted from a study by Rollnick et al. (1999), and was used as a basis for developing the coding systems for instruments 2 and 3. This was done in order to ensure comparability in the coding systems to make analysis of the data easier. If the coding systems are comparable then, it becomes easy to check on the consistency of students' responses on the 3 instruments, hence their validity could be established.

In this coding system (for instrument 1) the naming of the apparatus is considered less important than being able to recall how it was used. What is important is whether students are familiar with the use of the apparatus mentioned, in the sense that they have seen this apparatus before, either being used by the teacher in a demonstration or by the students themselves in their group activities. Although instrument 1 could establish students' practical experience, it could not tell whether students were having teacher demonstrations or not.

The coding system used distinguished between everyday familiarity, book familiarity and laboratory familiarity regarding remembered experience, and this is explained below as follows :

- **Everyday familiarity** means that the students recognised the apparatus according to how it is used in everyday life. For example, the use of a funnel in pouring paraffin into a pressure stove or in a paraffin lamp is one example of an everyday life situation. Another example could be that of a thermometer which a student observes when it is used at a clinic for checking a patient's temperature.
- **Book familiarity** is whereby students acquire information about the apparatus from reading a textbook, not necessarily having seen or touched them, either at school or outside school. This was shown by knowledge of names, rather than use of apparatus.
- **Some laboratory familiarity** simply means that students have seen some of the apparatus at school either being used by the teacher or by themselves in their group or individual activities.
- **Good laboratory familiarity** means being familiar with most of the apparatus as shown in the coding system. That is, students have either seen the teacher using most of the apparatus mentioned and they (students) have used them in their practical activities. or they have used them in their practical activities by themselves.

Thus the coding system used for instrument 1 is shown in Fig. 4.1 below:

Figure 4.1 **Coding system for instrument 1**

The question read:

In the pictures below are 10 pieces of laboratory apparatus, labelled A - J. Write down the names of any of these which you know. Then say if you have used it before and what you used it for (see appendix B).

For coding focus on laboratory apparatus A, B, C, D, F, G, I, J. Count the frequency of correct usage of these eight pieces of apparatus.

The following codes were assigned:

code 0 (no familiarity with apparatus) - if response form is totally blank, i.e. nothing written or responses are all wrong.

code 1A (everyday familiarity with apparatus) - if the names and uses of both E and H are correct and the use of 1 to 3 other items correctly explained but, indicating everyday use (e.g. use of a thermometer to determine patients temperature at a clinic, and a balance to weigh goods in a shop).

code 1B (book familiarity with apparatus) - if the names and uses of both E and H are correct and the use of 1 to 3 other items correctly explained or 4 to 8 names correct without giving their uses.

code 2 (some lab familiarity with apparatus) - if the use of 4 or 5 items (excluding correctly explained E and H) are correctly explained.

code 3 (good lab familiarity with apparatus) - if the use of 6 or 7 or 8 items (excluding correctly explained E and H) are correctly explained.

Note that E and H, that is the thermometer and the funnel were considered to be used commonly in everyday life, so were not considered as part of laboratory familiarity and thus used to establish a criterion for everyday use. These items were excluded in determining the other codes. Names of the apparatus were not important in determining laboratory familiarity as one could learn them from a book.

4.2.2 Peer validation of coding system

The above coding system was given to peers in the chemical education research group at Wits university for validation. There were 7 peers who participated in the validation of the coding system. Each person was given 4 completed questionnaires - one from each school - and the coding system used. The purpose of giving peers the questionnaires for coding was to find out whether they could come up with the same codes as the researcher. If they came up with the same coding as the researcher then that would mean that the coding system is reliable.

Out of the 7 peers who coded the students' responses, 5 came up with the same coding as the researcher. The other two had problems following the coding system. It does not necessary mean that these two could not follow the coding system completely. According to these two (as well as the other 5) a few points here and there needed attention.

There were certain points identified by the peers that needed some clarification. First of all peers pointed out that code 0 was not explained clearly in the coding system. Initially for one to obtain code 0 the response form was supposed to be mainly blank according to the coding system. Peers expressed concern about the word "mainly" saying that it is vague. Their question was "how many blanks in the form would be equal to "mainly"? After critically looking at the statement the researcher rephrased the statement for code 0. For a respondent to obtain zero the form had to be totally blank, that is nothing written at all. Another way in which a respondent could get a zero is when everything in the form is all wrong. The aim of this coding system is not to give respondents zero. That is why even if they gave names only they could still get 1B which is book familiarity.

Secondly, it was also pointed out by peers that there was no distinct difference between code 1A and 1B. Their main contention was the wording used which, according to them, was vague. For example, words like several and mainly were confusing. Also, a statement like "E and H correct" was considered vague by peers. They argued that it is not clear whether the statement meant the names of E and H should be correct, or the uses of E and H should be correct or, both the names and uses of E and H should be correct. Corrections were made to the coding system and vague statements were changed to avoid confusion.

After peer consultation the researcher decided that if students considered a beaker to be used for measuring volume this was accepted as many schools use it for that purpose. For other volume measuring equipment the expression, ' measure the amount of liquid' instead of measure the volume of a liquid was also accepted. Again if a student wrote a wrong name for a certain piece of apparatus, possibly because of the unclear representation of that particular apparatus, but gives the correct use of the piece of apparatus he or she mentioned, then that was accepted as well.

4.2.3 Results obtained for instrument 1

Data collected from the questionnaire was tabulated according to the number of correct responses per apparatus per school.

Table 4.1 below is a summary of the performance of students from the four participating schools. The table shows how many students got a certain code per school.

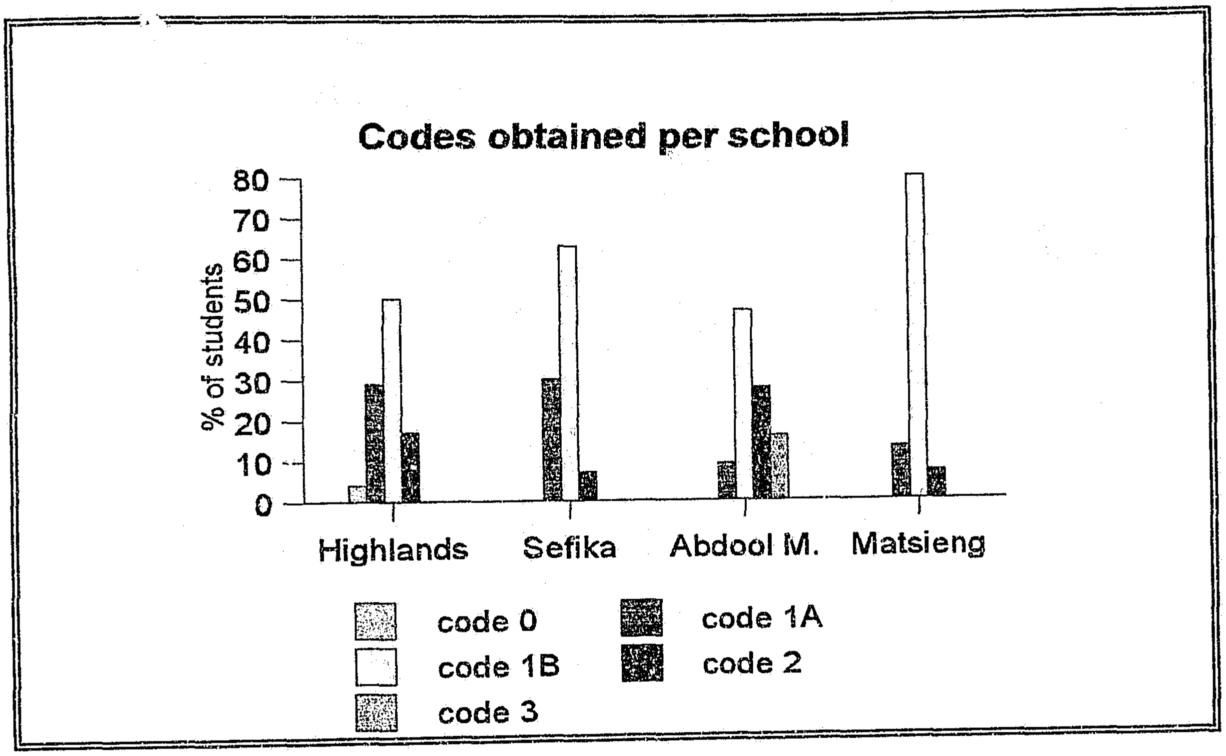
Table 4.1 Codes obtained in instrument 1 per school

	SCHOOL NAMES / NUMBER OF STUDENTS				
Codes	**Highlands (n = 24)**	**Sefika (n = 27)**	**Abdool Moosa (n = 32)**	**Matsieng (n = 15)**	**Overall number of students for the 4 schools (n = 98)**
0	1	0	0	0	1
1A	7	8	3	2	20
1B	12	17	15	12	56
2	4	2	9	1	16
3	0	0	5	0	5

Although instrument 1 could not pick up teacher demonstrations it could show students with everyday familiarity, book familiarity, some laboratory familiarity and good familiarity. Table 4.1 shows that overall students from the 4 schools did not have the opportunity to do practical work individually or as a group, as a result they had book familiarity.

The information in table 4.1 has also been represented in the form of bar-charts (figure 4.2 and 4.3). Figure 4. 2 shows codes obtained by students per school while figure 4.3 shows a comparison of codes obtained by students from the four schools.

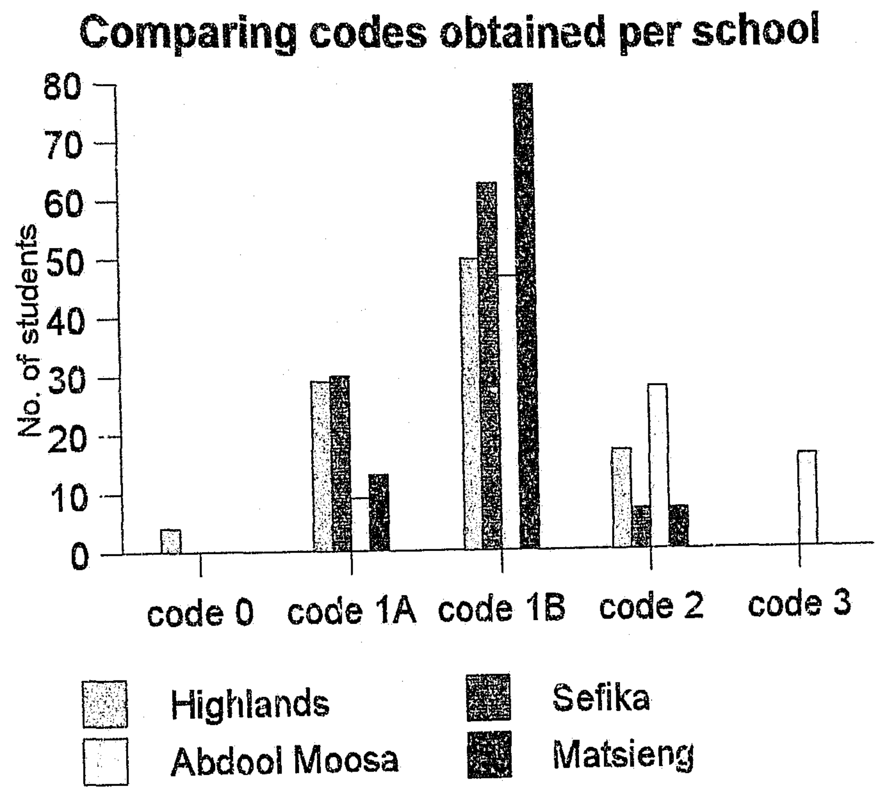
Figure 4.2 Codes obtained per school in instrument 1



The bar-chart (fig. 4.2) shows the same information as in table 4.1 except that in figure 4.2 the information is in percentages. Still what is dominant in the four schools is book familiarity and less laboratory familiarity.

Figure 4.3 below shows a comparison of the codes obtained by students from the individual schools. It shows a quick clear indication of how many students (in percentage) got a certain code per school.

Figure 4.3 Comparing codes amongst the 4 schools



From figure 4.3 it can be seen that good percentage of students from all the 4 schools have clustered under code 1B which is book familiarity, with Abdool Moosa as the only school having students with good laboratory familiarity. In as far as individual schools performance of students is concerned, Abdool Moosa high school is the best comparatively.

Table 4.2 below shows an overall picture of how the students performed in instrument 1. It (table 4.2) shows the percentages of students stating the correct use of each piece of apparatus.

Table 4.2 Number of students (in %) with correct use of each apparatus

	SCHOOL NAMES				
Name of apparatus	**Highlands** Percentage correct use n = 24	**Sefika** Percentage correct use n = 27	**Abdool Moosa** Percentage correct use n = 32	**Matsieng** Percentage correct use n = 15	**Overall %** correct use for all the school
Beaker	46	56	53	53	52
Dropper	13	30	47	0	23
B. burner	42	52	75	40	52
Balance	42	11	44	53	38
Thermometer	13	59	47	60	45
Burette	4	4	25	0	8
M. cylinder	13	4	31	7	14
Funnel	38	41	53	60	48
L. condenser	0	4	9	0	3
conical flask	4	4	63	20	23

Table 4.2 shows a vast difference in students' responses to the questionnaire from the four schools. One would expect students to show better familiarity with apparatus like the thermometer and the funnel as these are supposed to be common in everyday life. However, looking at the individual schools, Abdool Moosa high school shows best familiarity in comparison to the three other schools. The reason for better performance by Abdool Moosa high school could be because at this school students have practical examinations at the end of the year. One would also expect better performance from Highland high school students, a former "White" school, as it is better equipped with laboratory facilities. With the former Black schools one would not expect much because they do not have adequate material and human resources.

Another possible factor that could have contributed towards the low performance of the respondents is the diagrammatic representation of the 10 pieces of apparatus (see Appendix B). First of all the pieces of apparatus were not drawn to scale, hence making it difficult for the students to identify them. For example, some students confused a burette with a thermometer because the latter, in the diagram, was larger than the former. Secondly, the diagrams were in black and white not in colour. This could also have posed some problems to some students. A measuring cylinder was mistaken for a T-square, and an electronic balance for a bathroom scale.

Some students' responses were either incorrect or vague. Table 4.3 shows some of the vague or incorrect responses given by the students.

Table 4.3 Some of the incorrect or vague uses given by the students

Name of apparatus	**Incorrect or vague use** (Number of responses)
Beaker	to measure exact amounts (4), direct transference of electrons (1), make food tests (1), used for experiments (7), to pour some experiment (1), for testing (2)
Dropper	in the laboratory for experiment (2) , measuring purposes, (3) for testing (2), used for liquid (5)
Bunsen burner	initiate or provide energy for an endothermic reaction (2), for experiments at school(3), in chemicals (4), experiments (2)
Balance \ scale	to measure (1), measuring purposes (1), measure substances in science (1), measure amounts in titration (1), to measure powder (1), measure small..(1), measure quantities (1)
Thermometer	test for indicators (1), in a clinic when I was sick (1), experiments (2)
Burette	slowly accurate release (1), measure liquids (2)
Measuring cylinder	to measure the size (1), to measure and store substances (1), to measure quantities of substances (1), to pour out large quantities (1), for measuring the molecules (1), measure liquids (1)
Funnel	to a substance from one container to another (1), science (std 7) (1), in the laboratory for experiments (1), to pour reactants (1), to test for fats (2), for holding wool or solid (1),to pour reactants (1)
Liebig condenser	*only three students got the name and use correctly, the rest left the spaces blank
Conical flask	used to measure the final volume(1), to measure liquids (1), for practical in biology (1)

Note: The numbers in brackets indicate the number of students who gave the response.

4.3 Instrument 2

Instrument 2 was testing perceived experience.

4.3.1 Coding system for Instrument 2

The coding system for instrument 1 was used as a basis for developing a coding system for instrument 2 because of the fact that it (instrument 1) was validated by interview sessions. Once instrument 1 was validated it was used to validate instrument 2. The researcher looked through instrument 2 to find out what was portrayed by students' responses in terms of their laboratory experience. A coding system was then designed with reference to the students' responses to instrument 2.

In instrument 2 (see Appendix B), students were supposed to state the extent at which they have done practical work by ticking those choices that apply for each science subject [instrument 2 (a)], as well as describing their experience of practical work [instrument 2 (b)]. Th esearcher's focus was mainly on students' practical experience in chemistry.

Since there was more than one option to choose from, the researcher had to decide which combination of the options was to be allocated a higher coding (code 3). A higher code was given to students who claimed to have done many experiments by themselves, and the overall picture they gave in instrument 2 (b) of their experience of practical work. Therefore, a combination of 'I have done many experiments in chemistry' and "My teacher demonstrates experiments to the class in chemistry' were given a higher code than if students selected , "I have never done an experiment; no teacher demonstrations; nor read from books." A new code, to indicate teacher demonstrations was included here - it is not possible to distinguish this aspect in instrument 1. The final codi stem is shown in fig. 4.4 below:

Figure 4.4 **Coding system for instrument 2**

Code 3:	if students selected, "I have done many experiments" + " Teacher demonstrations." <u>or</u> if students selected, "I have done many experiments." only.
Code 2:	if students selected, "I have done a few experiments + Teacher demonstrations." <u>or</u> if students selected, "I have done a few experiments."
Code 2A:	if students selected, "Teacher demonstrations only."
Code 1B:	if students selected, "I have read about experiments."
Code 0:	if students selected, "I have never done an experiment; no teacher demonstrations; nor read from books."
Code U:	if students do not show a clear indication of whether they have done practical work: *(U means uncodable)*

4.3.2 Peer validation of the coding system

The coding system for instrument 2 was also given to colleagues for peer validation. Colleagues had no problems in following the coding system, though one of them suggested that it should be clear in the coding system whether the instrument is focusing more on chemistry than physics and biology, even if the title of the study states it. Below is a table which shows the codes obtained by the students in instrument 2 (a).

Table 4.4 Number of codes obtained in instrument 2 per school

	SCHOOL NAMES				
Codes	**Highlands (Number of students)**	**Sefika (Number of students)**	**Abdool Moosa (Number of students)**	**Matsieng (Number of students)**	**Overall number of students for the 4 schools**
0	2	0	0	0	2
1B	0	6	1	13	20
2A	14	14	10	2	40
2	2	7	7	0	16
3	6	0	14	0	20

It should be noted that instrument 2, unlike instrument 1, could cater for teacher demonstrations. Hence a new code (2A) for teacher demonstrations was introduced in this instrument. Table 4.4 shows that overall, students from the four schools had more teacher demonstrations than book familiarity unlike with instrument 1 where the dominant category was that of book familiarity.

Table 4.5 below shows some of the responses given by students from the four schools in as far as their practical experience is concerned [instrument 2 (b)]. The student numbers in table 4.5 also indicate the particular school which each student comes from. The first three digits stand for the code given to a particular school. For example, **100** is the code for Highlands high school. **200**, **300** and **400** are codes for Sefika, Abdool Moosa and Matsieng respectively.

Table 4.5 Some students' perceived practical experience

Student number	Students' practical experience
1006	Our school does mostly experiments in chemistry. It is good for learning experience, but what I think we the students should do the experiments ourselves. There is no better way to learn than with personal experience.
10010	It is the best school with hard working teachers. They do all experiments in front of the whole class.
10019	We have the equipment for the experiments and we do have experiments in class, but the teacher doesn't know how to express herself in the correct manner and make experiments interesting.
10024	I cannot say that I know a lot because I have never done an experiment on my own.
2005	At my school we are not very familiar with practical work because of lack of apparatus, with the few apparatus we have we can do certain practical work.
20014	At school we don't have many apparatus hence we are not having many experiments. But with the help that we get we try to do those that we can but at times were are successful, at times we are not because of the poor conditions.
20015	Our school has some apparatus of making experiments, for example, most of our experiments is theory, some we do make them, others we have to read about them.
20016	In our school we don't have any tools to do experiments, there are some tools but not enough. So most of the time what we do is what we get from the textbook. At least if we can get enough tools we can know things better because what you'll be doing is what we'll be educated enough.
3001	We did not do many experiments but the few that we have done were very helpful and interesting.
3002	Not much practical work is done. Theory is more emphasized. More practical work can be carried out to ensure a better understanding.
30017	Hardly done any experiments. Teacher usually does all the experiments and all we do is observe Our labs are not properly equipped.

30023	Experiments were generally done by teachers only. Only in matric did I perform an experiment in a group without the teacher performing any tasks.
4004	My school does not have equipment which are needed to do practical work. We finish a chapter by reading an experiment but not doing it practically.
4008	My school does not have much experience of practical work. The reason for this is that we don't have apparatus which are needed for practical work. So many of us don't know much about practical work and some of us know a little.
4009	Practical work in my school is less because the school has no apparatus and the laboratory is no longer working, it is damaged.
4002	In my school we have the laboratory but we don't use it. We have never done practical work in school.

The table above (table 4.5) presents what students from the 4 schools had to say about their practical experience in their respective schools.
Looking at what students from Highlands high school had to say about their practical experience, it is clear that despite the fact that the school is well equipped with laboratory apparatus and chemicals, students never had the opportunity of doing individual nor any group activities. Mostly what they were exposed at was teacher demonstrations.

According to the students at Sefika high school inadequate laboratory equipment has deprived them of doing more practical work. They argued that because of this crisis they had to do a few practical activities which were in the form of teacher demonstrations, and the rest had to be read from their text books.

The information in table 4.5 shows that, at least, students at Abdool Moosa high school had the opportunity of having group activities though most of the practical activities were in the form of teacher demonstrations. Sometimes students had to read some practical activities from their text books. Even though the students say this, remembered experience is higher at Abdool Moosa than with the other schools.

Different results were obtained from Matsieng high school. According to the students practical work was never done at their school because of lack of apparatus. They had to rely on their text books, that is, they read about experiments from their text books. This tally with what one student from Matsieng high school said during an interview session. During the interview, student 40011 when asked whether they do practical work at their school she said they did not. This is what she said, "…….Sizifunda encwadini kanjalo ukuthi sihlanganisa ini kuphela." Meaning that *We read from the books as to what to mix, and that's it.*

4.4 Instrument 3

Instrument 3 also looked at students experience

4.4.1 Coding system for Instrument 3

Like instrument 1, instrument 3 assessed students remembered experience. The coding system for instrument 3 was also constructed based on the coding system for instrument 1 for reasons already mentioned in chapter 3. In this instrument students were given a list of laboratory apparatus and were required to tick the relevant column showing the extent of their familiarity with pieces of apparatus (see Appendix B). Again, the focus was on students doing the experiments by themselves or having had teacher demonstrations with the former getting a higher code. Table 4.6 shows the coding system.

Table 4.6 Coding system for Instrument 3

Combinations	Done it myself (number of ticks)	See the teacher do it (number of ticks)	Never seen it only seen a picture	Do not know what it is	Code
1	>5	any	any	any	3
2	>4	>1	any	any	
3	>3	>2	any	any	
4	3	1	any	any	2
5	2	<3	any	any	
6	1	>3	any	any	2A
7	0	>1	any	any	
8	0	0	>5	any	1B
9	0	0	>2	>2	
10	0	0	0	>8	0
11	0	0	0	any	

Please note: "any" means that any number of ticks obtained is insignificant in determining the code

4.4.2 Peer validation of the coding system

This coding system was given to colleagues, as well, for peer validation. Peers found it easy to follow but, suggested that an explanation of the mathematical symbols and the meaning of the word “any” should be done. The explanation was done as shown above.

Table 4.7 below shows the number of students from 4 schools that are within the respective code categories.

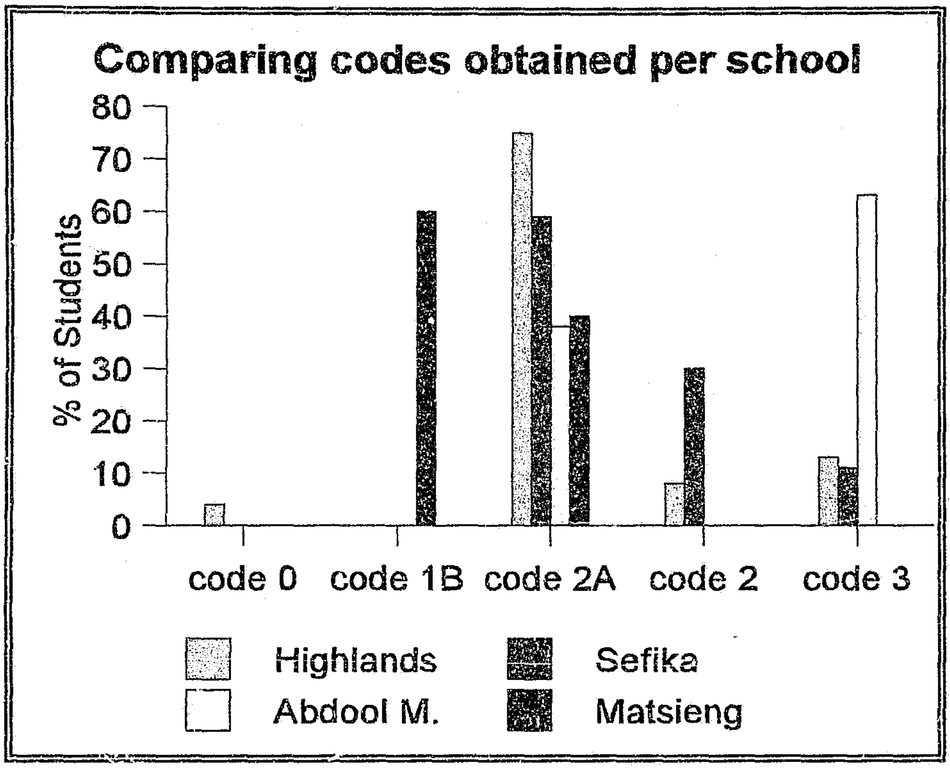
Table 4.7 Number of codes obtained in instrument 3 per school

Codes	Highlands (n = 24)	Sefika (n = 27)	Abdool Moosa (n = 32)	Matsieng (n = 15)	Overall number of students for the 4 schools. (n = 98)
0	1	0	0	0	1
1B	0	0	0	9	9
2A	18	16	12	6	52
2	2	8	0	0	10
3	3	3	20	0	26

The information in table 4.7 shows that overall, students from the 4 school had more teacher demonstrations than individual or group activities.

Figure 4.5 below shows the comparison of codes obtained per school in the form of a bar-chart. According to the bar-chart 60% of students from Matsieng had book familiarity with the remainder claiming teacher demonstrations. As far as teacher demonstrations areconcerned, all 4 schools fell under this category with Highlands showing the highest percentage. Abdool Moosa again has a higher percentage of students with good laboratory familiarity. Nevertheless, the overall picture shown by figure 4.5 is that students were exposed to more teacher demonstrations.

Figure 4.5 **Comparison of codes obtained at the 4 schools**



4.5 Student interview sessions

The interview schedule was in two parts. The first part of the interview schedule requested exactly the same information as instrument 1 except for two things. First of all, the apparatus were real and, secondly, students gave verbal responses instead of having to write them down (For the actual words used in the interview session see appendix C). The second part of the interview schedule consisted of questions mainly about their practical experience, and the nature of the questions will follow later.

The analysis of data obtained in the first part of the interview schedule was done in exactly the same way as in instrument 1. This means that the coding system used in analyzing data collected in instrument 1 was again used in this case. Table 4.8 below shows the analysis of data collect in the first part of the interview schedule. The total number of students interviewed was 16, four students per school as mentioned in chapter 3.

Table 4.8 Codes obtained

Student number	Interview code obtained
1001	2
1002	3
1003	2
1004	1B
2001	1B
2003	1A
2005	1B
20018	1B
3007	1B
3008	1B
30030	2
30031	2
4001	1B
4005	1B
4007	1B
40011	2

Overall the students interviewed had book familiarity according to the codes obtained in table 4.8 above. It is not surprising to see Abdool Moosa high students having both book familiarity and some laboratory familiarity. In instrument 2, which was looking at students' perceived experience, they mentioned the fact that they had the opportunity of doing group activities though there were more teacher demonstrations.

As far as Sefika high school is concerned, they did a few practical activities which most of them were teacher demonstrations according to what they said in instrument 2. This could be the reason why the data in table 4.9, above, shows Sefika students having book familiarity. It should be noted that the first part of the interview schedule, like instrument 1, could not tell whether students had teacher demonstrations.

Matsieng students were very consistent in their responses to the first part of the interview schedule. They had book familiarity which exactly corresponds to what they said in instrument 2. The situation at Highlands high school is rather strange because students obtained different codes. It could be that students, though in the same school, had different educational backgrounds or different remembering capacity.

Table 4.9 below shows a summary of the codes obtained by the 16 students from the four schools.

Table 4.9 Summary of codes obtained in the interview by the 16 students

Codes	Highlands (n = 4)	Sefika (n = 4)	Abdool Moosa (n = 4)	Matsieng (n =4)	Overall number of students interviewed (n = 16)
1A	0	1	0	0	1
1B	1	3	2	4	9
2	2	0	2	0	5
3	1	0	0	0	1

Again, as in instrument 1 the overall picture given by table 4.10 shows that more than 50 % of students who were interviewed had book familiarity.

In the second part of the interview session students were asked to answer the following questions: (a) Do you do practical work at your school? (b) How often do you do practical work? And (c) How is it arranged (teacher demonstrations or otherwise)?

According to students from Highlands high school, practical activities were done frequently, about three to four times a week. They also mentioned that practical activities in most cases were done by the teacher. There were no ind[illegible]r group activities. The teacher did everything with or without the students' assist[illegible]re to observe and fill in worksheets.

When asked whether they do practical work at their school, student 1002 (S1002) said:

> "The teacher does all the work. [The teacher did experiments] every time we start a new section. She just showed us what happens. What colour changes, bad smell. Stuff like that."(S1002)

S1002 told the researcher that they have never done experiments as a group, not even individual activities. When asked whether the teacher did some measurements during her demonstrations. S1002 told the researcher that,

> "She never actually measured. She did just like to estimate, not exact amounts." (S1002)

S1002 also mentioned that he liked practical work because he enjoyed it. He believed that its easier to learn when doing practical work because one can actually see what is happening.

The second student (S1001) when asked whether they did practical work at their school she said:

> "We don't do it ourselves. Some students do but, mostly the teacher does it. The teacher asks someone else to help her." (App.D, S1001). S1001 told the researcher that if they worked in the book, "and there is an experiment to be done, she [the teacher] does it."

The third student (S1003) told the researcher that they often did practical activities about 4 times a week, and that the person who did the activities was the teacher. What the students did was to listen and observe what the teacher was doing. When asked whether they have done any activities individually or as a group, S1003 said, "No."

S1004's account was that they did practical activities about 4 times a week.

> "Most of the periods when we go to science we do practicals." (S1004).

She went on to mention that whenever an experiment was done, the teacher did it. All they did [students] was to watch and write down their observations.

Note: App. D in parenthesis denotes Appendix D

Students at Sefika high school gave different accounts on their practical experience at this school. Student 2001(S2001) when asked as how often did they do practical work, she told the researcher that:

"Not very often, to be honest. So far we have done very few experiments in physical science especially. We have only done a few experiments in chemistry. In physics we haven't done any experiments. But at least in biology we have done plenty." (S2001)

She (the student) gave an account on how the practical activities were done.

"We did them as a class and then someone, like, a student would come forward and conduct the whole thing and then if we can't find something then, the teacher would come and help us where may be we can't may be do well." (S2001)

The second student (S2003) still from Sefika high school told the researcher that they did not do practical work often. She was not very sure as to how often practical work was done at her school, especially in chemistry. This is what she had to say:

"In a month I think about.....some of them they are many but, I actually see them in biology because in biology we do them a lot. But in physical science we don't. We do them once in that time, that's all or twice." (S2003)

The researcher asked S2003 to cite an example of an experiment they have done. S2003 gave an example where they (students) were "testing how charges go through a conductor." She also gave some examples from biology. The researcher asked S2003 to name the apparatus that was used in these experiments.

"Bunsen burner, even spatula, even the test tube." (S2003)

The researcher asked the student to describe a bunsen burner because the very same student could not identify this piece of apparatus in the first part of this interview, and this is what S2003 had to say:

"It is like...eh... fire comes from it. It has even spirit inside. Yah." (S2003)

It is clear that this student is used to a spirit lamp hence that's why she confused a bunsen burner with a spirit lamp. This illustrates a potential problem with instrument 1.

The third student (S2005) from Sefika high school had the following to say about his school practical work:

"We are not familiar with practical work because of lack of apparatus. The chemicals that we have, have just arrived, its too late now... and they are like micro. So we cannot use like to satisfaction." (2005)

According to this student there were little group activities (2 at the most) and there were no individual activities at all.

"The teacher did it for us. He then gave us a chance to do it, some of us." (S2005)

The fourth student (S20018) still from Sefika high school gave the following account in as far as his practical experience is concerned:

> "This year we did practical work two times. Last year we never did any. The teacher chose two people to assist her and she told them to mix something and showed to the whole class." (S20018)

When asked whether they have done any practical activities in a group, he said:

> "Yes we have done it once. It was on titration."

About the overall arrangement of practical activities he said:

> "Mostly they are done by the teacher. She would, may be, choose two students to help her." (S20018)

According to students from Abdool Moosa high school practical activities were done every time they came across a section that required them to do a practical activity. Though most of these practical activities were teacher demonstrations, students had a chance of doing a few individual activities for their practical examination at the end of the year. There were some group activities as well. S3007 gave the following account of his practical experience:

> "When we start a new subject we first do the theory and then the practicals after that, once a week. We have done one or two experiments for practical work on our own where the teacher has just watched us. Just guided us and watched us. And some other experiments he did it in front of the class where we watched." (3007)

About individual practical activities S3007 said:

> "No. We haven't done those. Individually? No....no... in a group."

According to S3007 they have never done any individual activities. It is all about teacher demonstrations and some group activities only.

Student S30030 when asked how often did they do practical work at their school he gave the following account:

> "We wouldn't say how many times in a week, of course according to the syllabus, mostly we have done the experiments for chemistry for one term. Like we did about mostly 5 experiments that's all in a term. The way the teacher sets out the apparatus we have fun and on top of that we understood it well and we will remember it." (S30030)

He continued to say that:

> "[The teacher] shows to us, after that he helps us and we do it ourselves. We do it in groups." (S30030)

The third student (Student 3008) said the following about practical work:

> "We do practicals, but not all of the practicals. More of theory than practicals. Once in three weeks." (3008)

When asked as to how the practical activities were done he said:

> "The teacher had everything set up on his desk and he showed it to us. The teacher was demonstrating. In science the teacher demonstrated everything to us.
> (S3008)

The fourth student (S30031) told the researcher the following about practical work :

> "Practical work, quite honestly we have only done practical work this year. We have done practicals but not us as pupils, our teachers have only done practicals...the experiments for us. And this year we did a few experiments ourselves for our practical marks. The teacher does the experiment in front of the class and we all are observers." (S30031)

As for the students from Matsieng no chemistry practical activities were done at all. According to the students the teacher told them that because of lack of laboratory equipment they were not going to do any practical activities. The students also mentioned that they also read about practical activities from their text books.

Student 4007 (S4007) when asked how often they did practical work, she said:

> "No. We haven't done that. The teacher says we don't have the apparatus."
> (S4007)

When asked whether they have ever been to the laboratory to do practical work, she said:

> "Not at all."

Student 40011 (S40011) when asked whether they go to the laboratory for experiments or use the classroom, had the following to say:

> "No, we don't do them. We just talk about them." (S40011)

Student 4001 told the researcher that they (students) did practical work sometimes.

"During our periods when we were studying we used to do experiments. Sometimes. Mostly in biology, not in chemistry." (S4001)

And lastly, student 4005 (S4005) had the following to say about practical work:

"Ah.... we don't usually do practical work because we don't have enough equipment. We did 3 or 4 experiments last year. The teacher was showing us. He was the one putting the solvents and the compounds, and we were watching." (S4005)

According to students' responses to the interview session the overall picture one can draw is that there is little or no practical work done at the four schools. A student from Sefika high school (S2005) confessed that they did little of practical work, "*We are not familiar with practical work because of lack of apparatus. The chemicals that we have, have just arrived, its too late now....*" Where there is practical work, it is more teacher demonstrations than group or individual activities.

Only students from Abdool Moosa high school had the opportunity of doing individual activities. The reason for this individual activities was because of their end of the year practical examination, as S30031 argues "*.....and this year we did a few experiments ourselves for our practical marks.*" Other than that there are a few group activities (not in all the schools) and almost no individual activities.

What is common with the schools in as far as practical work is concerned, except for Matsieng high school, is teacher demonstrations. For various reasons, which will be mentioned later in section 4.6, practical activities had to be demonstrated by teachers. What the researcher gathered from the students is that teachers did practical activities themselves, not students. In some cases the teachers would ask one or two students to assist them during the practical activities, as S20018 puts it, "*......The teacher chose two people to assist her, and told them to mix something and showed to the whole class.*" Other than that, teachers did the experiments themselves while the students watched and also wrote down their observations.

Matsieng high school is an exceptional case in the sense that they did almost no practical work at all. According to Matsieng high school students they were unable to do practical activities because of lack of apparatus. This is supported by S4005 who moaned, "*Ah.....we* *don't usually do practical work, we don't have equipment.*" S4007 also said the same thing about practical activities, "*We haven't done that. The teacher says we don't have the apparatus.*" The situation at Matsieng was worst compared to the other three schools because most of the time students had to rely on their textbooks. That is, they read about experiments from their textbooks as S40011 argues, "*We don't do it. We just talk about experiments.*"

4.6 Teacher interview sessions

Two physical science teachers at each of the four schools were interviewed about students' practical activities. Teachers from the four schools were given different codes in order to identify them with their respective schools. For example, TH1 is teacher 1 from Highlands high school. TS1 teacher 1 from Sefika, TA1 teacher 1 from Abdool Moosa, and finally, TM1 stands for teacher 1 from Matsieng high school.

The following is what transpired at Highlands high school:

Teacher 1 (TH1) told the researcher that students at Highlands high schools do not do practical activities by themselves, they watch teacher demonstrations. The teacher argued that there is no time for such things as individual or group activities. This is what the teacher had to say ,

> "We got sufficient equipment but its a question of time and also the setting up, we do not at this stage have a laboratory assistant." (TH1)

When asked how often he did demonstrations TH1 said that,

> "When they are necessary. Because it depends now, OK, at this stage I have got up to Grade 10 where a lot of the chemistry is theoretical work and there is not much practical work involved."(TH1)

Teacher 2 (TH2) confessed that they do have enough laboratory apparatus but the biggest problem was space. She said that there is not enough space for students to do their own experiments. She said,

> "What's happening now is that I 'm doing demonstrations for them, and then the result I have to pass around the class because I sit with 52 matrics in one class. There is not even enough space for them to sit. So that's my biggest problem but, actually I think it's working well because the moment I do

experiments they are really interested to see the results. The only problem is that they cannot do that themselves because, first of all we don't have a laboratory assistant and the class is big and there is no working place." (App.D,TH2)

At Sefika high school teacher 1 (TS1) when asked whether students do practical work this is what she had to say,

"Not really because of lack of equipment. May be once in a year. One practical work in a year. So there is no practical work at all. Unless you take them [students] out to Funda centre. That's where they will see practical work." (TS1)

When asked whether she has taken them to Funda centre she said,

"Yes I have done that before. I organise with Funda centre for them to go there and see some experiments which I am unable to do at school. But again it also depends on how important it is to you as a teacher. What is your aim. What do you want to achieve out of it." (TS1)

The teacher was asked to elaborate on what she had just said. And this is what she had to say,

"Like for instance, when I realise that I can't go on if there is no observation on the section, and I can't explain that through theory and I am forced to conduct an experiment, then I have to arrange with somebody at the centre. So most of the time in a year I do take them out." (TS1)

Teacher 2 (TS2) from the same school told the researcher that the school received some chemicals and some micro equipment from Chemistry Telcom late last year (1999). The teacher explained that,

"All along what the school did was to organise some video cassettes so that they could observe experiments rather than do experiments. That is the past 2 to 3 years the school organised those cassettes; otherwise before then it was just mere theory." (TS2)

This implies that the students who were involved in the research never had or had little chance of using the equipment donated by Chemistry Telcom. When TH2 was asked as to how often did the students do practical work, this is what he had to say,

"In chemistry what I do is I go through the lesson, the theory part and then thereafter its then that I give them a chance to experiment. On very few occasions where they do the experiment first and observe before I give them the answer but they also do that. Sometimes it is mere demonstration on my side because of trying to economize the few chemicals which were donated. Sometimes I can organise them in groups and again I make sure I save on the side of chemicals because I don't have much since the donation last year, so I'm trying to economize." (TS2)

Teacher 1 (TA1) from Abdool Moosa high school told the researcher that students at his school do practical activities. When ask how students do practical activities, this what he had to say,

> "The children are broken up into groups, because obviously we don't have enough equipment for each child or each learner to handle. What we do we break up into groups of 4 or 5, sometimes 6. Right? And then each group has a set of apparatus, then we have enough. Then they carry out the experiment on their own after I have demonstrated. I demonstrate it once and they carry out the experiments on their own, each group." (TA1)

When ask how often do students do practical work, he said,

> "They do practicals +/- twice a month. Well there is a set amount of practicals that we have to carry out in Grades 11 and 12. It's about 12. You space them during the course of the year. But that's for chemistry and physics, not just chemistry specifically." (TA1)

Teacher 2 (TA2) also from Abdool Moosa high school told the researcher that students do practical activities though it is more of teacher demonstrations. He said,

> " They did but, mostly it was demonstrations because we don't have enough apparatus, the laboratory facilities. Mostly I demonstrated because we don't have, in this room, even a single tap. We have the laboratory and the store room at the back there. There is no tap, no gas. So we don't have even a single bunsen burner which is the most essential tool." (TA2)

When ask how often are practical activities done he said,

> "The facilities are not there. So I don't have a laboratory that can make everybody to participate. So whenever it is possible I demonstrate. It depends on the topics."
> (TA2)

Students at Matsieng high school rarely did practical activities. This is what teacher 1(TM1) from Matsieng high school told the researcher. He said he did practical activities,

> "only when I feel it is necessary, like eh... during chemical reactions in organic chemistry, because we don't have enough equipment and chemicals." (TM1)

He also mentioned that if he needed some chemicals he would go to Funda centre where experiments can be done.

When asked as to how he organised practical activities, this is what he had to say,

> "A day before I prepare all I need, the apparatus and chemicals. During the science period they come and I personally do the experiments. I don't give them chance to do that because of lack of laboratory equipment. Besides that I don't think the students know how to use this equipment. They got to be trained right from Grade 10. Some of them see this equipment for the first time in Grade 12."(TM1)

Teacher 2 (TM2) from Matsieng high school told the researcher that during the past four years students did not do any practical work, only theory was done. It's only this year (2000) that they are doing practical activities. This means that the Grade 12 students that were part of this study never did any practical activities at all. When asked as how he orginised practical activities, TM2 said,

> "First I demonstrate the experiment then I give them [students] chance to do the experiment by themselves." (TM2)

Teacher 2 (TM2) told the researcher that students were unable to do individual activities because of lack of apparatus. In most cases they share as a group. They do the experiments as a group.

From what the teachers said during the interview sessions a lack of laboratory equipment seemed to be the main problem in as far as the schools are concerned, except for Highlands high school where this was not the case. At Highlands high school what bothered the grade 12 science teachers was the teacher to student ratio which was high. According to the teachers, there was not enough space for the students to have individual or group activities. As a result of a lack of space and time, practical activities were done in the form of teacher demonstrations only. The teachers also pointed out that a lack of laboratory assistance was short coming in as far as doing practical activities is concerned.

Despite a lack of laboratory equipment students at Abdool Moosa managed to perform group activities, though most of the activities were teacher demonstrations. Sefika and Matsieng high schools rarely had any practical activities due to a lack of laboratory equipment. If they were luck_ _o do any practical activity it was teacher demonstrated.

4.7 Concluding remarks

This chapter looked at the coding systems of instruments 1, 2 and 3, their development and how they were used to code students' responses to the three instruments. Teachers' responses were used to check on the reliability of students' responses to the instruments.

According to data obtained from instrument 1, the overall picture is that students from the four schools had limited opportunities to do individual or group practical work. Hence they had book familiarity in as far as the coding system of instrument 1 is concerned. There was evidence of some laboratory familiarity and good laboratory familiarity shown by students from Abdool Moosa high school. It should be noted that, as mentioned earlier, instrument 1 could only pick up everyday familiarity, book familiarity, some laboratory familiarity and good familiarity not teacher demonstrations.

Instrument 2 , on the other hand, catered for teacher demonstrations as well. Unlike with instrument 1 where book familiarity was dominant, in instrument 2 teacher demonstrations were dominant. This corresponds with what students wrote about their practical experience that they had more teacher demonstrations than group activities.

Instrument 3, like instrument 2 produced teacher demonstrations as the dominant category. Overall, students from the four schools had a higher proportion of teacher demonstrations with Highlands high school having the highest percentage. On the other hand Abdool Moosa high school still had the highest percentage of students having good laboratory familiarity.

Students' interview responses from the first part of the interview schedule gave an overall picture of students having book familiarity as in instrument 1. Matsieng high school students were very consistent in their responses, while on the other hand there was some inconsistency with Highlands high school students.

It should be remembered that the first part of the interview was an oral version of instrument 1. For the second part of the interview schedule students from all four schools expressed almost the same problems, though different in magnitude depending on individual schools' material supplies (laboratory equipment). Students argued that due to a lack of laboratory equipment they did little of practical work which in most cases were teacher demonstrations. There were few, if any, individual activities and group activities were minimal. At Matsieng high school, there was almost no practical work. According to the students, they had to rely solely on their text books.

Teachers also echoed the problem of a lack of laboratory apparatus hence leading to practical activities being done mostly as teacher demonstrations. This corresponds with what the students said in their interview sessions. Schools like Sefika and Matsieng (both from the Black township) had done little or no practical work at all. The situation about lack of laboratory apparatus was alarming. The researcher had the opportunity of personally surveying the laboratories at these schools and what he saw was a disaster, almost no laboratory equipment. At Matsieng it was worse because the laboratory was closed due to its deteriorated conditions. According to the teachers at these two schools, students had more theory than practical work.

At the other two schools (former Indian and former White schools) the problem of lack of apparatus was less severe than the other two schools. According to the teachers at Highland high school (former "White" school) students at least had the chance of watching teacher demonstrations. They had no problem with material supplies. The problems were caused by large numbers of students in classes, little space for individual or group work, time, and absence of a laboratory technician. As a result, students never had any individual or group activities.

At Abdool Moosa high school (former Indian school) the situation was better because according to the teachers, students had the opportunity of watching teacher demonstrations, as well as having group activities. Although most of the practical activities were teacher demonstrations. S3001 confirmed this during an interview with the researcher, she said,

> *"Practical work, quite honestly we have only done practical work this year. We have done practicals but not us as pupils, our teachers have only done practicals...the experiments for us. And this year we did a few experiments ourselves for our practical marks. The teacher does the experiment in front of the class and we all are observers." (S30031)*

In conclusion, it should be noted that students' perceptions (as well as teachers') in as far as lack of material supply is concerned were based on their own situations. For example, students at Abdool Moosa high school complained that they did not have adequate laboratory apparatus, but if they knew the situation at Matsieng high school they would have a different perception. Student at Matsieng high school would envy them.

Data presented in this chapter will be analysed in the next chapter, that is, chapter 5.

CHAPTER 5

DISCUSSION

5.1 Introduction

This chapter discusses data that was presented in chapter 4. The main focus of this chapter is to compare data collected from instrument 1 and the interview sessions of the students. The purpose of looking at these data is to establish the validity of instrument 1, that is, to see whether instrument 1 measured what it was supposed to measure. After establishing the validity of instrument 1, it was used to validate the other two instruments (instrument 2 and 3).

5.2 Comparing data from instrument 1 and interview sessions

Instrument 1 was validated using interview response data from the 16 students who were interviewed. Interview responses of the 16 students were matched with their instrument 1 responses. Interviews were used to validate instrument 1 because interview responses are a fair reflection of reality. Data were presented in the form of codes that the students obtained both in instrument 1 and the interview sessions and compared on a one to one correspondence (see table 5.1). Teachers' responses in their interview sessions were used in a complementary way to support or negate their students' responses.

Table 5.1 shows the comparison between data obtained from the 16 students' responses to instrument 1 and the first part of the same students' interview sessions. It was decided that coded responses of the two categories would be considered to be consistent if they differed by less than two levels, for example, 1B for instrument 1 would be consistent with 2 in an interview and vice versa. This decision was made with the belief it is an acceptable range of variation. Responses from both the interviews and instrument 1 were coded using the same coding system.

Table 5.1 Data from instrument 1 and interview sessions

	Instrument 1	Interviews
Student number	**Code**	**Code**
1001	1B	2
1002	**1A**	**3**
1003	**1A**	**2**
1004	1B	1B
2001	1B	1B
2003	1A	1A
2005	1B	1B
20018	1B	1B
3007	1B	1B
3008	1B	1B
30030	**1A**	**2**
30031	2	2
4001	1B	1B
4005	1B	1B
4007	1B	1B
40011	1B	1B

Table 5.1 above shows consistency in most students' responses to instrument 1 and the interviews, though there are a few inconsistencies, particularly with students from Highlands high school. These students performed well in the interview sessions because the researcher verbally probed their responses. The very same students performed poorly in the written instrument 1 in the sense that they obtained low codes as compared to the interview session. There may be several reasons for this state of affairs. It could be that some of the diagrams presented in instrument 1 were not clear enough for these particular students to identify, or they misinterpreted the instructions. But if one looks at table 4.1 in chapter 4 one may argue that students from Abdool Moosa performed well in this instrument with about 44% of the students obtaining higher codes (codes 2 and 3). If other students could identify the pieces of apparatus it could mean that the

diagrams were not that confusing. Probably the students who could identify some of the pieces of apparatus did not know, and never used those particular pieces of apparatus, hence they left blanks.

Therefore, the reason mentioned above may not be justifiable. Another reason could be that these particular students were better at verbal than written response. Possibly they were not interested or unwilling to think when filling in instrument 1, but with the interview session may be they felt obliged to say something because the researcher was there waiting for responses. One could also argue that perhaps the coding system was flawed, however it was peer validated. All these are speculations. Examination of the questionnaire reveals that the reason for these low codes was blank forms rather than wrong answers. Hence the last reason is most likely.

What was observed by the researcher, for example, was that students 1002, 1003, and 30030 did not fill in all the spaces in instrument 1 but, in the interview session a high proportion of apparatus was identified. Hence that is why there is this difference in codes obtained by these particular students. Thus it appears that data from these students could be discarded because their responses to instrument 1 do not appear to be a reflection of their practical experience.

Students from Sefika high school showed consistency throughout. The four students interviewed obtained the same codes in instrument 1 as well as in the interviews. Three of the four students indicated book familiarity while the other student showed everyday familiarity.

Students from Abdool Moosa high school also showed some consistency in their responses except for one student (S30030) as already indicated above. Two of the four students interviewed at this school had book familiarity, one showed some laboratory experience. The fourth student (S30030) was not consistent in his responses.

In the fourth school (Matsieng high school) all students were consistent in their responses. The four students interviewed had book familiarity.

So apart from students who left blanks, responses for the instrument and the interviews were consistent.

5.3 Validating instrument 1

In order for instrument 1 to be valid, it has to measure what it is supposed to measure which is to establish students' remembered chemistry practical experience. Lubben *et al.* (2000) say "It is important to note that validity is not a characteristic of the data collection instrument but the data themselves, although the format of the instrument may influence the validity of the data collected." This implies that what one gets (data) from a collection instrument is very important in terms of validity. The format of the data collecting instrument is also very important because it determines the kind of data that will be collected (see chapter 2). The format of instrument 1 was validated (see Rollnick et al., 1999).

It is also important to note, as Lubben *et al.* (2000:p.87) point out that "the same instrument may be tested and found to produce highly valid data in one context, but may generate data of low validity when used in another context." This statement suggests that the format of the data collecting instrument should be in such a way that in takes into consideration the context of the study. Rollnick et al.'s (1999) instrument took care of the context of the study because the pieces of laboratory apparatus used in their study (and the current study) were common. Common in the sense that they can be easily accessible to schools. There are two sophisticated pieces of apparatus that may not be easily accessible to other schools (the Liebig condenser and the electronic balance). These two pieces of apparatus were deliberately included to establish the standard of practical experience the four schools provided their students. Data obtained in instrument 1 was validated by the interview sessions.

In table 5.1 there is some consistency in the 16 students' responses to instrument 1 and the first part of the interview session. The overall picture obtained in table 5.1 was that students showed book familiarity.

This section will proceed to look at what students had to say about their practical experience in the second part of the interview, as well as teachers' views about practical work at their schools.

In as far as the students' interviews are concerned the general impression obtained from their responses was that there were more teacher demonstrations or no practical activities at all. In some cases, for example Matsieng high school, there was hardly any practical work according to the students and the teachers concerned. According to what the students at this school said, the situation that prevailed was due to lack of laboratory facilities. When asked how often do they do practical work their school (Matsieng), S4005 said, *"Ah..we don't usually do practical work because we don't have enough equipment."*This was confirmed by the interviews with physical science teachers at the participating school. The teachers also stated that due to inadequate laboratory facilities students did not have the opportunity to do group work, let alone individual work.

Students and teachers did however reported a small amount of group practical work at Abdool Moosa high school which is reflected by code 2 that some students obtained (see table 5.1). Students at this school have to sit for a practical examination at the end of the year (see table A, Appendix D), may be this is the reason why they were given the opportunity of at least having group activities.

Despite the fact that Highlands high school had adequate laboratory apparatus, students still did not have that opportunity of doing practical activities. In the interviews teachers argued that

1. they had a large number of students in one class (more than 50 students)
2. there was a lack of working space due to the large number of students
3. they were short of time (may not have time to finish the syllabus), and
4. there was a lack of a laboratory technician.

On the surface these arguments appear reasonable. However, there are ways of dealing with large numbers of students. One way is to divide the students in groups and let them come to the laboratory at different times. When the researcher suggested this, one teacher argued that they may not have time to finish the syllabus. On the other hand, students at Abdool Moosa high school performed very well even though they did not have a laboratory technician nor sufficient laboratory apparatus like Highlands high school. The practical experience at Abdool Moosa allowed for some group work. The question is whether teachers are dedicated enough to their work.

Table A (Appendix D) looks into the responses of both teachers and students to the interview sessions in a more specific way. The table gives a description of student and teacher responses about practical work. What follows, then, are specific impressions of the whole situation.

According to the information in table A, students and teachers from Highlands high school agreed in their responses in as far as practical work is concerned at their school. First of all, there was no mention of a lack of apparatus from both teachers and students. Instead TH1 made a bold statement:

> "We got sufficient equipment........"(TH1)

Secondly, both teachers and students mentioned the fact that they did practical activities, though they were teacher de...onstrations.

> "The teacher does all the work every time we start a new section. She just showed us what happens........"(S1002) and

> "What's happening now is that I'm doing demonstrations for them......" (TH2)

In as far as teachers and students from Sefika high school were concerned the state of practical activities at their school was not encouraging because of a lack of apparatus. Students seldom did practical activities. The researcher obtained this information from both the teachers and students during the interview sessions. These is what some of the respondents had to say:

> "Not very often, to be honest. So far we have done very few experiments in chemistry..." (S2001), and TS1 said,

> "Not really because of lack of equipment. May be once in a year...."(TS1)

A lack of apparatus led to teacher demonstrated practical activities and, group activities were rare.

At Abdool Moosa high school practical activities were in the form of teacher demonstrations and group work. This is what was pointed out by both teacher and students during the interview sessions.

> "[The teacher] shows us, after that he helps us and we do it ourselves. We do it in groups."(S30030)

> "The children are broken up into groups, because obviously we don't have enough equipment for each child or each learner to handle. Then they carry out the experiment on their own after I have demonstrated."(TA1)

There was no agreement as to how often practical activities were performed at the school (Abdool Moosa high school). The rate at which practical activities were done, according to teachers and students, ranged from once a week to 2 practicals a month. Respondents' views may not always portray the actual situation and this is crucial in terms of validity. However, this disagreement does not affect instrument 1(remembered practical experience) but, could affected instrument 2 which deals with students' perceived practical experience.

Students at Matsieng high school rarely did any practical activities. If they were lucky to have a practical activity it was bound to be a teacher demonstration because of a lack of apparatus. This is an account from both teachers and students from Matsieng high school.

> "We haven't done that. The teacher says we don't have the apparatus...." (S4007)

> "Very rarely. Only when I feel it is necessary........because we don't have enough equipment and chemicals.' (TM1)

Some conflict was observed at Matsieng high school from students and teachers responses. Teachers' responses concurred with only two of the four students that were interviewed and who indicated that practical work was done as teacher demonstrations. The other two indicated that no practical work was done at all.

The responses of both the teachers and the students overall corresponded with each other. interview sessions. Both the teachers and students overall, appeared to give a true reflection of the real situation at their respective schools.

Another point to raise is the issue of biology practicals. Three out of four students at Sefika high school mentioned, in passing, that they did more practical activities in biology than in chemistry (see table A appendix D). The fact that this study focused more on chemistry may have influence some students' responses. Some students may have thought that to have practical experience is having done more chemistry practicals. For example, two students from Matsieng high school claimed that they did not do practical work at all, but one student (S4001) pointed out that they did practical work though it was in biology not in chemistry (see table A appendix D).

Students' biology experience could have affected their ability to do the questionnaire in the sense that some (if not all of them) of the pieces of apparatus may have been used in biology experiments. Students could have easily transferred their biology practical work experience to chemistry practical work to deal with the questionnaire.

The last point to pick up is that of micro-scale equipment. Towards the end of last year (year 2000), Sefika high school received a donation of science laboratory micro-scale equipment (see TS2 and S2005, table A appendix D). Fortunately, they did not have much time to use them. Had it been that they were using this type of equipment all the years, that would have negatively influenced their performance in the questionnaire. They would not have been able to identify the 10 pieces of standard laboratory equipment in instrument 1. Although the naming was not important, the identification was crucial to enable them to tell whether they have used a particular piece of apparatus. The students may have used micro chemistry kits extensively and have had practical experience which would go undetected by the instrument.

As it has been mentioned in the previous chapters, instrument 1 could only account for everyday familiarity, book familiarity, some laboratory familiarity and good laboratory familiarity. It gave an overall picture of students in the four schools having book familiarity. However, interview responses indicated the prevalence of teacher demonstrations, which could not be detected by instrument 1. This was also evident between instrument 1 and instrument 2 where a relationship was established (see section 5.3.1 below). Most of the students who obtained code 1B in instrument 1 got 2A in instrument 2 (see appendix B, table A). What this means is that many of these students (with codes 1B) were actually exposed to teacher demonstrations. Within these limits, instrument 1 has succeeded in measuring what it was supposed to measure, hence it is valid. As a result of its validity, it can be used to validate the other instruments, namely instruments 1 and 2. What follows now is the validation of instrument 2.

5.3.1 Validating instrument 2

In order to validate instrument 2 data from this instrument was looked at in relation to data obtained from instrument 1 (see table A, appendix B). Table A shows a comparison of responses to instruments 1 and 2 for the 98 students who participated in this study. What can be seen in table A is that most of the students with book familiarity (1B) in instrument 1 were coded as teacher demonstrations in instrument 2, while the rest of the 1B's maintained the same code in instrument 2. It is clear then, that there is a relationship between instrument 1's coding of book familiarity and teacher demonstrations.

Those students who obtained a combination of 1B and 2A or instruments 1 and 2 respectively, were actually exposed to teacher demonstration since instrument 1 could not detect teacher demonstrations. It is not in all the cases that students with 1B were actually exposed to teacher demonstrations. Sometimes book knowledge was actually book knowledge as is the case with Matsieng high school. These statements are confirmed by what the teachers and students from Matsieng high school reported in the interview sessions. For example, S40011 said "No, we don't do them [practical activities]. We just talk about them." A teacher (TM2) from the same school pointed out that "......for the past four years we have been doing only the theoretical part of physical science."

Common combinations were picked up from table A (appendix B) and their frequencies established. Some combinations were considered to be consistent while others were not. The criterion used to establish consistency of the combinations has already been explained in chapter 4.

Table 5.2 displays the combinations obtained from responses (from 98 students) to instruments 1 and 2. The combinations in bold are the ones that are considered to be consistent. These combinations will determine the validity of instrument 2. That is to find out whether students' perceived practical experience can be considered to be valid given the kind of data at hand. Students could give different views in as far as their practical experience is concerned, hence affecting the validity of the data collected.

Table 5.2 Combination of codes obtained from instrument 1 and 2 for the 98 students

Combinations		Frequency
Specific remembered experience (instrument 1)	General remembered experience (instrument 2)	
1A	1B	6
1A	2A	6
1A	2	6
1A	3	2
1B	1B	16
1B	2A	22
1B	2	8
1B	3	12
2	2A	9
2	2	2
2	3	4
3	2A	3
3	3	2

A careful look at table 5.2 shows a common trend with the combinations, except for 2 sets of combinations of which one is regarded as consistent. In all the other combinations, the codes in the second column (instrument 2) are higher than in the first column (instrument 1). In the first column (instrument 1) are codes showing students'specific practical experience while in the second column (instrument 2) are codes showing students' "snap shot" practical experience.

One should be aware that individual students' perceptions in as far as practical experience is concerned may not necessarily be the same, nor can they be the true reflection of the real situation. Any students may give his/her account of the situation the way he/she feels. Sometimes it may involve a personal agenda, for example, in a case where a students is not in good terms with a certain teacher or even the school as a whole. It also could be the other way round, where the students try to give a good impression of their teachers and the school.

Also, the way perceived data is collected is vague (see sample of the questionnaire, appendix B, instrument 2). For example, the use of words like 'a few' and 'many' is confusing. How many experiments are considered to be many or a few? It is not indicated in the instrument. The second part of the instrument does not give students a clue as to what kind of practical work is required, and whether to mentioned how it was done (individual, group or teacher demonstrations).

A closer look at all the combinations (see appendix B, table A) shows that over 40 students had code 2A (teacher demonstration). This excludes Matsieng high schools students who all had 1B (book familiarity) from both instrument 1 and 2, except for two students who claimed to have had teacher demonstrations. What the researcher is trying to establish here is the reliability of some of the students' responses to instrument 2 and the combinations that result out of this. For example, combinations like (1B, 2) and (1B, 3) or instruments 1 and 2 in table 5.2, one could argue that they could as well be (1B, 2A) for reasons pointed out above. Also, the interview responses reveal that most students had more teacher demonstrations than group or individual activities.

What one can say is that in most cases perceptions tend to be 'rosier' than reality. That is, for some reasons perceptions are inflated unlike the findings by Lubben et al. (2000).

Another option to establish the validity of instrument 2 is by comparing data obtained from this instrument on students' "snap shot" practical experience to what students said in the second part of the interview sessions. Table B (appendix D) shows the comparison between data obtained from instrument 2 and the second part of the interview sessions.

What can be seen (Table B, appendix D) is that students from Highlands high school did not give consistent responses to the interview sessions and instrument 2.

> "The teacher does all the work every time we start a new section. She just showed us what happens....." (S1002, interview)