THE RELATIVE MERITS OF DIFFERENT METHODS OF TEACHING EXPERIMENTAL WORK IN A TOWNSHIP SECONDARY SCHOOL IN THE REPUBLIC OF SOUTH AFRICA.

Mavis Buyisiwe Mabuya

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.

Johannesburg, February 1993

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 Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

Mavis Buyisiwe Mabuya

MBMabuya

8th day of February 1993

ABSTRACT

The purpose of this study is to determine which of the methods of teaching experimental work, namely; demonstrations, filmed-experiments or illustrating experiments using the chalkboard, is the most effective method of teaching pupils at the secondary school level.

Forty-two Standard Eight Physical Science pupils from a township secondary school, registered under the Department of Education and Training and situated on the East Rand, served as the subjects for this study. Pupils were divided into three equivalent groups, each with similar marks in science and each group was exposed to three different teaching methods for three different topics. The pupils wrote a test for each topic after the exposure to one of the methods.

The research data were statistically analysed, using non-parametric statistics (viz., the t-test). The analysis of the data indicates that none of the methods was consistently superior to the others.

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to:

My supervisors, Dr. K.C. Naik and Prof. J.D. Bradley, for their guidance, direction and willingness to help throughout this study.

My close friend, Absolom Mathebula, who spent hours typing this report and also for his understanding, encouragement, continued interest and unfailing support.

My school principal, Mrs L. M. Mokoena, for her encouragement and for granting me permission for this study to proceed at the school.

The pupils for co-operating so well in this investigation.

My colleagues, Mandla Luvuno, Gcina Makathini and Reggie Dlakavu for their valuable advice and unselfish assistance during this study.

TABLE OF CONTENTS

LIST OF APPENDICES

Page

CHAPTER I

INTRODUCTION

1. INTRODUCTION

Science subjects like Physical Science and Biology can be taught purely theoretically to the pupils at both the primary and the secondary schools levels. Science syllabuses, however, emphasise the important role of experimental work in science education. Research has shown that the experimental work when done with the pupils facilitates teaching and promotes meaningful learning of scientific principles and concepts (1). Experimental work can be presented in many different ways. It can be presented as something to talk about, using a chalkboard to illustrate or by watching it on the screen (filmed experiments) or by demonstrations done by the teacher or by doing it individually or in small groups (hands-on experiments) (1,2,3).

Intensive studies have been done on hands-on experimental work and on demonstrations (2,4). In both cases, the advantages outweigh the disadvantages. In fact, experimental work, if appropriately done enhances learning (2). However, in reality, many constraints hamper the implementation of experimental work especially in the township secondary schools in South Africa. Despite these constraints in the township secondary schools, experiments are taught. It is noted that some teachers prefer using one method of teaching experimental work over the other.

2. BACKGROUND TO PROBLEM

The Department of Education and Training (D E T) has introduced experiments in Physical Science for the senior secondary students (matriculants) since 1987. These experiments include mainly the Inorganic Chemistry section in the standard nine syllabus. These experiments are compulsory as the knowledge of them is assessed on the written examination paper, at the end of the standard ten year (Appendix J). These questions encourage pupils to memorise facts about what they had done a year ago. It is perceived that experimental work plays an important role if it is done by pupils on their own, since they (pupils) can remember better what they have done. Experimental work done individually or in small groups can lead to meaningful learning, provided a teacher gives clear explanation about the experiment to be performed. This process of participation will make the pupils remember what they have learnt easily. However, in the D E T schools because of the lack of laboratories, of chemicals and equipment, lack of teachers with necessary skills of conducting such work, and a large number of pupils in classes, it often is not possible to carry out individual or small group experimental work. Because of these logistical problems, teachers resort to the use of the chalkboard, video experiments and demonstrations as a means of teaching the experimental work.

3. RESEARCH PROBLEM

Under the prevailing unfavourable circumstances which of these three methods of teaching experimental work (chalkboard, filmed experiments or demonstrations) can result in better understanding of the prescribed science syllabus. It was decided to address this question in respect of the standard 8 syllabus topic on the reactivity of some elements. The decision was made, despite the original interest in standard 9 inorganic chemistry, because the standard 9 pupils and teachers have no time for extra work because of the workload in this standard. It is therefore felt that the standard 8 pupils and and teachers will be more cooperative.

4. RESEARCH HYPOTHESIS

According to Tuckman (12), a hypothesis helps to formulate an expectation of the outcome of the study, and it gives the relationship between the concepts identified in the problem. In the present research the following null hypothesis was made: There is no significant difference between the average test marks of pupils who were exposed to the demonstration method, the chalkboard method or the filmed experiment method.

4.1. Variables

In this study the independent variables are the teaching methods and the testing to which pupils were subjected. The dependent variable is the achievement of pupils measured b testing, as specified by the objectives (Appendices A, B and C). The intervening variable is learning, for it theoretically affects the observed phenomena but it cannot be seen, measured or manipulated (12).

5. PURPOSE OF STUDY

The purpose of the study is to determine which of three commonly used methods of presenting experimental work, can result in better recalling and understanding of the subject matter taught.

6. IMPORTANCE OF THE STUDY

The evaluation of the methods of presenting experimental work is important since the results from this study will indicate which, if any, of these methods of greatest value in the teaching of Physical Science in township secondary schools where there are many constraints.

The findings of this study are also important because the future development of science teaching aids and the extent of provision of science equipment by the D E T could be greatly influenced by the experimental data.

The study will also guide the teachers when selecting their teaching methods. They may be helped to weigh the pros and cons, perceive the difficulties experienced by the pupils when exposed to each method, and how to help them if possible.

7. LIMITATIONS OF THE STUDY

(i) The knowledge that the pupils are being used in this experiment might cause some pupils to try harder than they usually do (the Hawthorne effect).

(ii) It is not possible to isolate all of the factors that influence learning - for example, extraneous variables such as socioeconomic standard and individual learning aptitude, thus limiting the generalizability.

(iii) The subjects are from one D E T secondary school in the East Rand area of the Republic of South Africa, thus resulting in further limitations to the generalizability of any findings.

8. STATEMENT OF ASSUMPTIONS

(i) It is assumed that all subjects (pupils) had acquired basic knowledge of Standard 7 Physical Science concepts, since Standard 8 Physical Science pupils were involved in this study.

(ii) It is assumed that the measuring instruments are reliable and valid.

9. DELIMITATIONS OF THE STUDY

(i) Only a certain section on metals and non-metals of the Standard 8 Physical Science syllabus was tested.

(ii) The population is delimited to Standard 8 pupils from the same township secondary school.

CHAPTER II

REVIEW OF THE RELATED LITERATURE

1. AIMS AND OBJECTIVES OF EXPERIMENTAL WORK

A number of aims and objectives of experimental work have been highlighted in the literature on science education (5,15, 16,17). Toothacker (5) summarizes them into three categories:-
(i) to support lectures,
(ii) to promote good scientific attitudes,
(iii) to teach laboratory skills.
Hodson (17) added to these another two categories:-
(iv) to motivate, by stimulating interest and enjoyment, and
(v) to give insight into scientific method and develop expertise in using it.

Chamber (in Toothacker (5)) and many other educationists (18, 19) list the major objectives of experimental work and state that one of them is "to illustrate lecture courses" or "to illustrate, supplement and drive home points from lectures." Kruglak (19) in his study divided students into three groups. One group had a conventional laboratory class, a second group had the experiments demonstrated to them and the third group had no laboratory contact at all. There was no significant difference found between any of the groups on lecture theory examination. Toothacker criticised the use of the laboratory to elucidate theory, and he suggested that if experimental work has a place in the curriculum, it must stand on its own and not [illegible] support lectures.

Wh[illegible] [illegible]portance of experimental work is largely undisputed ([illegible]) the qu[illegible]y of what actually takes place in laboratories varies widely, as surveys have shown (26,27). Perception by teachers varies and the structures needed to support and maintain experimental work have never been fully resolved in many instances. It is noticed that it is unlikely to make a contribution to science teaching until these issues are tackled. There are a number of reasons why experimental work is important but different individuals favour one reason over the other. In this regard more emphasis (26) is laid on experimental work as a means of reinforcing the understanding of concepts and principles, and thus teachers do experimental work in order to support the lectures (5) or to illustrate, supplement and drive home points from lectures (18,19).

It is also noted that in countries where science inspectors do not visit schools in order to assess experimental work but it is assessed through written examinations, many teachers prefer demonstrations rather than allowing students to do hands-on experimental work due to constraints that exist (21). Paper and pencil tests are quite satisfactory for assessing "visual-aid" aspects of experimental work (28).

In reality, assessment of experimental work is not a straight-forward enterprise and it requires more than the usual paper and pencil test to cover all the outcomes of experimental work. Generally, it is recommended (29,30) that experimental work should be assessed by teachers (internal assessment) and that it should be done continuously so that most of the aims and objectives of experimental work are achieved. The internal assessment may be moderated externally to ensure that the assessment results are valid (as is the case with schools under the administration of the House of Delegates- Department of Education and Culture- Indian Education Department and the Natal Education Department) (34).

2. MERITS OF DEMONSTRATIONS

Some educationists (20,21) think that demonstrations should be used to fill a largely supportive role, that of confirming the theory which had already been taught. They also recommend that, there should be no time lag between theory and illustration (23). A skilful demonstrator can encourage observation, rather than tell students everything, and together the students and the teacher can make deductions from these observations. Meaningful learning can result if demonstrations can be linked properly with the theory taught in class (4). Demonstrations are also needed as a means of communication: teachers should not rely on verbal instruction only.

Newbury, quoted in Connell (2), says "The demonstration method lesson is, of necessity, more definite in content than hands-on experiment. Thus, while it is effective for all pupils, it is particularly helpful to weaker pupils.... boys on the whole, prefer the individual method, and the girls the demonstration method.". Few science teachers doubt that secondary school science courses should contain a significant amount of experimental work carried out by pupils themselves (6). Some research studies have revealed that, in many cases, pupils do experimental work without a clear idea about what they are doing or what lies behind the experiment (5). They need a clear explanation given by their teachers.

Many teachers believe that pupils should have first hand practical experience in laboratories in order to acquire skills in handling apparatus, to measure and to illustrate concepts and principles (6,7,11). Unfortunately experimental work often does not go further than this and few opportunities are provided for pupils to conduct challenging investigations (6). Colussi in his study mentions that many teachers are more satisfied with demonstrations than individual, or small group hands-on work because of the social pressures for good results. The examination system does not emphasise the assessment of abilites, attitudes and skills associated with the experimental work. Newbury (in Connell (2)) stresses that although the majority of experiments should be individually performed, the general usefulness of demonstrations must be stressed, for they are effective and economical in supplying knowledge.

Barger (22) criticized hands-on experimental work because he claimed, that his students mastered the work just as well, if not better by demonstration experiments because observations and discussions were stimulated to a greater degree. The Spens Report, 1938, discusses experimental work (2) at length. It quotes with approval the Thomson Report, and gives a clear and emphatic statement of the case for demonstrations: ".......a larger variety of experimental work, covering more ground and carried out more accurately and skilfully, will provide more data over a wider variety of topics than is possible where only, or in the main, experimental work is done by the pupils. By a greater use of good demonstration we believe that science teachers will more commonly stimulate wonder and imagination.".

Demonstrations can make an exceptional contribution to teaching and learning for they can be used, for example, for setting problems and for arousing the interest of pupils (1,8,23). They are even used to illustrate the safety aspects of experiments, to stimulate further thought, and to carry out class experiments that are too dangerous for pupils to tackle by themselves.

Many countries, other than Britain, have until recently kept experimental work to a minimum because of the high cost and constraints involved in running laboratories. Laboratories on an average require twice the space of a conventional classroom for the same sized class. They are expensive to equip with the necessary services including equipment and ancillary staff that is required to maintain the laboratories (1,3). When the hands-on experimental work is done more money and time are spent, as compared to when demonstrations are done by their teachers. Mundangepfupfu (36) outlines effective course management strategies that can reduce the expenditure on facilities for hands-on experimental work in favour of more demonstration facilities in the ordinary classroom. He also encourages alternative methods and experiments that do not need to be taught in the laboratory.

Hodson (17,35) claims that research evidence and theoretical arguments both show that "practical work as presently organised (in U S schools) is largely unproductive and patently unable to justify the often extravagant claims made for it."

3. MERITS OF VIDEO EXPERIMENTS

Many schools may lack the financial means of providing adequate facilities, equipment, and materials for the performance of extensive experimental work. There may be administrative problems, such as non-availability of laboratory space at the "right time". This fact makes it difficult to integrate experimental work fully with other chemical education activities to which the learner is exposed (10). Recognising the problems which may hinder the implementation of a laboratory based approach to subjects like Physical Science and Biology at a high school level, filmed experiments have been conducted as an alternative to normal hands-on experimental work and demonstrations (8).

Kempa and his co-workers, quoted by Ben-Zvi (10), reported the usefulness of filmed demonstrations in the acquisition of manipulative skills. They suggested that films may be an effective medium for the teaching of manipulative skills even when laboratory facilities for personal practice are not readily available. Despite some of the advantages of filmed instructions, Carpenter and Greenhill (quoted in Ben-Zvi (9)) point out that pupils feel that less is learned from filmed instruction than from conventional teaching (lecture-method).

A study on the effectiveness of filmed experiments as an alternative to the hands-on experimental work in the context of high school chemical education was carried out by Ben-Zvi and her co-workers (10). The main result of the study was that the attainment of cognitive abilities and of laboratory-oriented problem-solving skills was not significantly affected by this approach. For full appraisal of the educational usefulness of filmed experiments as an alternative to "live" laboratory experience, it is necessary to consider not only cognitive and psychomotor skills developed in students, but also their reaction and attitudes towards the alternative teaching medium. Slabough (24) reported a positive attitude of students towards such vicarious experience. But Watson (25) in his study concluded that film-teaching over long periods leads to loss of interest and the development of negative attitudes towards science.

Data related to cognitive objectives of experimental work, for example, the drawing of inferences from experiments and their understanding of chemical theory, revealed that, the attainment level of pupils taught using films and of pupils who were exposed to teacher demonstrations was practically identical (9).

Filmed experiments have advantages over teacher demonstrations, in that they can be shown over and over again without the time-consuming task of preparing and rehearsing each time as is the case with demonstrations (24). However, most pupils prefer teacher demonstrations because they can be allowed to ask questions during the session and the teacher might provide them with answers (9,24).

4. MERITS OF CHALKBOARD METHOD

The chalkboard is a widely used teaching-aid . Most of the teachers are trained in how to use it. They are more confident when using it than other teaching aids and every school has a chalkboard. It is the cheapest aid because one does not require electricity in order to operate it nor to purchase chemicals and equipment to be used; only piece of chalk is needed.

When the chalkboard method is used, pupils do not observe real experiments but they are told about them. In some cases they cannot even imagine what is being said or done in terms of various skills required for experimental work- cognitive skills, laboratory skills, communicative skills and deductive skills. Nevertheless when classrooms are overcrowded or lacking in all other resources it may be the only available method. No report in the literature could be found that dealt with the merits of the chalkboard method as a means of teaching experimental work.

CHAPTER III

RESEARCH METHODOLOGY

1. PILOT STUDY

This study was carried out before the main part of the research was undertaken. The pilot study was intended to test the validity and the reliability of the testing instrument (12,14) and to determine whether the planned strategy of conducting the study was feasible. In this study the Standard 9 pupils were involved because of the small number of pupils who were doing Physical Science in Standard 8. A topic different from that chosen in the main research was used (redox reactions), because these pupils had already been exposed to these topics. Three groups of pupils (equivalence among groups was established using previous test marks) labelled A,B and C were randomly selected, and they were taught experimental work by means of the three teaching methods. Group A was taught by means of the chalkboard method. Thereafter this group was allowed to go for break, but was not allowed to interact with Group B or

Group C. While Group A was having a break, Group B and Group C were exposed to a filmed experiment and teacher-demonstration, respectively and simultaneously.

At the end of these lessons they were allowed to write a co test. The average mark of the pupils who were exposed to th demonstration method was the largest.
The successful administration of the pilot study showed tha it is possible to carry out the research in this manner.

2. SELECTION OF SUBJECTS

2.1. Target population

The standard 8 pupils doing Physical Science through the medium of English in one township school in the Alberton ar registered under the D E T, were used for the study.

2.2. Sample

A number of class tests on another part of the syllabus wer written by the pupils and the marks obtained were used to establish equivalence among the three groups (A, B & C). The pupils' average marks were ranked and used to assign pupils into three different groups, that is, the pupil who obtained the highest average mark was placed in group A, the pupil with the second highest average mark was placed in group B, the pupil with the third highest average mark was placed in group C and so on. The groups were randomly assigned to different teaching methods. Initially each group consisted of nineteen pupils but due to unforeseen circumstances, was reduced to fourteen pupils. The sample size is suitable and is regarded as feasible, since small-sample statistics assure the researcher of acceptable reliability in estimating sampling error, before making decisions about his data. It is also noted that a sample size between ten and thirty has some practical advantages: it is quick to work with and facilitates calculations. Also this sample size is large enough to test the null hypothesis but it is small enough to overlook weak treatment effects (14).

These three groups were exposed to the same topic (Appendices A, B and C) but were taught using different methods. Each group was exposed to each of the methods for the three different experiments, as shown in Table 3.1. The pupils wrote a common test for each experiment.

The research design was as follows:-

Experiment	Video	Demonstration	chalkboard	Test
1	Group A	Group B	Group C	1
2	Group B	Group C	Group A	2
3	Group C	Group A	Group B	3

Table 3.1 - Sequence of the research procedure.

3. EXPERIMENTAL INSTRUMENTS

3.1. Description of the methods of teaching experimental work.

3.1.1. Demonstration method

The experimental procedures were compiled from different text-books and chosen to suit the existing laboratory conditions. The demonstration experiments were done by the teacher (the researcher). The teacher weighed out the masses of the substances to be used for an experiment, labelled the test tubes or beakers and arranged them as highlighted in the experimental procedure. All these preparations were done before the pupils came to the laboratory session, so as to avoid unnecessary delays in the laboratory.

The title of the experiment was written on the chalkboard. The scheme of report was also written on the board and the pupils were expected to answer or fill in the missing information. When they came to the laboratory, they were allowed to copy what was on the chalkboard. They wrote the answer for each question after each demonstration.

The teacher also drew their attention by asking some questions during a demonstration (Appendices A, B and C). Some of these questions were not on the chalkboard. Answers were given during the lesson. Pupils were allowed to sit close to one another, to ask questions, to answer questions and to talk to one another, so as to make the situation more normal.
At the end of the demonstration session they moved to the classroom, where they were going to write a test. On their way to the exam room they discussed what had been demonstrated.

3.1.2. Chalkboard method

The teacher (the researcher) told the pupils the topic of the lesson and even wrote it on the board. While teaching the teacher wrote down the main points on the board, for example, the chemical equations, the colours observed when elements were heated in the presence of oxygen and the order of activity of elements with oxygen. During the lesson pupils were permitted to write the notes in their books.
After the lesson they went for a break. The length of the break

was determined by the length of the demonstration session. During the break they did communicate within the group while other groups were busy with other methods.

In both the chalkboard method and the demonstration method, one pupil in Group A in particular asked many questions and he scored 40,9% and 54,5% respectively. As a result of this questioning one can say this group was most actively involved because the teacher permitted the pupils to answer some of these questions.

3.1.3. Video method

A colleague who was not familiar with physical science showed the filmed experiments to the pupils. They sat in positions where they could see the film clearly. The video was shown once only. Some of the pupils made notes. The video was never interrupted.

The demonstrator in the filmed experiments announced the title of the experiment and it was also flashed on the screen. He mentioned the purpose of each experiment. The worksheet to be completed was written on the board. He pointed out the position of the elements to be studied on the periodic table. He displayed these elements on the working bench. The apparatus was used and oxygen was kept ready in the gas jars. He talked loudly about whatever he was going to do, gave the reason for each action carried out and told them what they should observe. For example, he said; "I am going to warm lithium metal, observe how easily lithium melts, observe the colour of the flame formed.". After each demonstration, he filled in the objectives of the experiment as written on the chalkboard. To show the colour of the substance, for example, the colour of the flame or metal oxide, coloured boards were pinned on the chalkboard. Whilst writing on the chalkboard he kept on talking too. After carrying out the whole demonstration, he pinned up relevant balanced chemical equations. At the end, he summarised the findings and gave conclusions on what appeared on the board. As he was busy with the demonstration the board was behind him and the pupils could see what had been written. Some of them kept on writing whilst he was continuing with the demonstration thus disturbing their concentration. The pinned up chemical equations were pre-made and that made the lesson to be too fast for pupils to follow and sometimes they copied without understanding. But, all in all, the set up was fairly good.

When the pupils came out of the video-room, most of them complained, for example; (i) about the speed of the video, (ii) that the language was complicated (English at a first language level was used whereas they are taught through English at a second language level), (iii) about the intonation of the speaker, (iv) that nobody was available to explain the subject-matter where they did not understand, (v) that it was not possible to ask questions and (vi) that the video was not replayed. This group was completely passive during the film session and they only talked to one another on their way to the exam-room.

The video films used were prepared by Mr E.G. Jansen, senior Physical Science subject adviser, in the D E T . Some of the D E T schools do have these video films. It is noted that in some of these schools, these video films are used to substitute a teacher's lesson or when the class is too large.

There are no courses given to guide a teacher on how to use these video films and when to use them. The teachers used their own discretions in showing the video film.

None of the pupils brought the prescribed Physical Science textbook to school during the research, although all the pupils had copies.

3.2. The post-test

The three tests are included as Appendices D, E and F. They were allocated 22, 23 and 22 marks respectively. The nature of the questions was such that only one correct answer could be correct. All tests consisted of two different types of questions. Some of the questions were testing what pupils had observed or been told about the experiment by the teacher. Other questions referred to background theory such as a knowledge of balancing the reaction equations by inspection. In terms of Bloom's taxonomy, the tests were testing simple recall or basic knowledge and comprehension. The tests were written on the chalkboard, and the researcher invigilated and marked the scripts.

4. VALIDITY AND RELIABILITY OF THE EXPERIMENTAL INSTRUMENTS

4.1. Content validity of the post-test instrument

In order to ensure content validity, the test of achievement must be judged in relation to the learning objectives for each experimental topic as shown in Appendices A, B and C. When drawing up the tests, the pupils' textbooks were studied and subject content specialists were consulted.

The textbooks that were consulted are: "Physical Science Standard 8", Brink and Jones (1985) and "Complete Physical Science Std 8", Brits, Eloff and Botha (1988). My two supervisors, Dr. Naik and Prof. Bradley scrutinized the test questions. On their advice, certain questions were reworded to avoid ambiguities and inaccuracies and then the revised test was administered to the pupils.

4.2. Reliability of post-test

The test questions have only one answer. No independent marking was carried out because of the uniqueness of the answers. The memorandum of each test was prepared in advance of marking of the test.

5. TREATMENT OF RESEARCH DATA

A non-parametric test, namely the t-test, was used to determine whether there was any significant difference in the average marks obtained in the three different methods of teaching the experimental work. This test assumes that the samples are drawn from a normally distributed population and allows one to estimate the parameters of such a population. This test also assumes that the scores obtained are independent of each other and that they constitute a representative, unbiased sample from the underlying population (33). This test can also be used when the total number of scores is less than thirty. The t-test was employed to test the hypothesis of this study because it can be used to determine the difference between two or more means. The generally accepted 0,01 and 0,05 level of significance in educational research was used (35).

The following formula was used when calculating the "t" value:

$$t = \frac{\sqrt{N - 1} \cdot \Sigma d}{\sqrt{N \Sigma d^2 - (\Sigma d)^2}}$$

t = the t-value

d = the difference between the paired scores

Σd = sum of the difference of paired scores

Σd^2 = the sum of the squared difference scores

N = the number of pairs.

CHAPTER IV

ANALYSIS OF FINDINGS

The three experimental groups were exposed to three different teaching methods and they also wrote three different tests, following the sequence shown in Table 3.1 (Chapter 3, p. 23). The actual marks obtained by the pupils for the different methods are included in Appendices G, H and I. The mean marks and standard deviations for each test are summarised in Table 4.1. The mean marks were taken as a measure of the effectiveness of the teaching methods in achieving certain objectives. Observational objectives are specified in the description of the experiments in Appendices A, B and C. But, in addition to these, there were objectives related to the balancing of the chemical equations for the reactions which were demonstrated.

TEST No.	DEMONSTRATION	VIDEO	BOARD
1 $\bar{x}$	A= 9,86	C= 6,50	B= 8,86
sd	A= 3,92	C= 3,25	B= 3,42
2 $\bar{x}$	B= 12,00	A= 14,00	C= 11,00
sd	B= 3,88	A= 5,76	C= 4,66
3 $\bar{x}$	C= 8,07	B= 7,43	A= 11,50
sd	C= 4,75	B= 3,55	A= 3,43

Table 4.1: Means and standard deviations for each group for each post test.

As can be seen in Table 4.1, by comparing the mean scores, in test 1, the demonstration method appears to be the best method compared to the chalkboard method or video method since the mean of the group exposed to the demonstration method is the highest. In test 2, the video method seems to have been better than the other two methods. In test 3, the chalkboard as a means of illustrating the experimental work seems to have been the best method.

In the light of the foregoing results one cannot really tell which of these methods is in general the best.
It is also noted that pupils in Group A attained the highest mean in each post-test.

The data was analysed further using the non-parametric t-test. The results are shown in Table 4.2.

Groups	Test 1	Test 2	Test 3
AB	0,84	2,33*	2,77*
BC	1,90	0,21	0,47
AC	2,35*	1,68	1,98

Footnote: * - Not significant at the 1% level, but significant at the 5% level.

Table 4.2: Summary of t-calculated values.

The critical t-values for a two tailed test with 13 degrees of freedom are 2,160 at 5% level of significance and 3,012 at 1% level of significance. From the results obtained it can be seen that there is no significant difference in achievement of pupils at 1% level of significance, which implies that the null hypothesis may be accepted at 1% level of significance- viz., that there is no significant difference between the average test marks of pupils who were exposed to the demonstration method, the chalkboard method or the video method.

According to the t-calculated for test 1 (comparing groups A and C - demonstration versus video) and test 2 (comparing groups A and B - demonstration versus video) the null hypothesis may be rejected at 5% level of significance but not at the 1% level of significance. In test 1 (comparing groups A and C) it is in favour of the demonstration method but in test 2 (comparing groups A and B) it is in favour of the video method. The t-calculated values in test 3 (comparing groups A and C) suggest that there is a significant difference between the average mark of the group that was exposed to the chalkboard method and the average mark of the group that was exposed to the video method, and thus the null hypothesis should be rejected in this case at the 5% level.

When one looks at Table 4.1, one can say that Group A performed better in all the tests. This group appears not matched to the other groups irrespective of the method they were exposed to.

Further first degree (basic) analysis was done to determine which of the methods under study will enable pupils to score better in the questions that are related to observation and to the theory respectively. The results obtained by each pupil in each test, appear in Appendices K, L and M. The letters O and T represent observation and theory respectively. The total marks for observation questions were 8, 12 and 5 in test 1, test 2 and test 3 respectively, while the total marks for the theory questions were 14, 11 and 17 in test 1, test 2 and test 3, respectively. In test 1, questions 1, 2, 4 and 6(ii) were classified as the observation questions while the remaining questions were considered to be the theory questions. In test 2, questions 1(a), 1(b), 1(c) and 4 were classified as the observation questions whilst the remaining questions fall under thoory. In test 3, questions 3 and 4 were classified as the observation questions and the remaining ones as theory questions.

The average marks and the percent average mark obtained by each group are as follows;

	DEMONSTRATION			VIDEO			BOARD		
	Grp	O	T	Grp	O	T	Grp	O	T
Test 1	A	3,64	6,21	C	2,43	4,07	B	3,00	5,86
%		45,5	44,4		30,3	29,1		37,5	41,9
Test 2	B	6,71	5,29	A	6,86	7,14	C	5,50	5,50
%		55,9	48,1		57,1	64,9		45,8	50,0
Test 3	C	1,43	6,64	B	0,50	6,93	A	1,50	10,0
%		28,6	39,1		10,0	40,8		30,0	58,8

Table 4.3: Summary of average marks and percentage average marks for the observation part and the theory part in each test.

The % score ratios (O:T) were also determined as shown in Table 4.4. In terms of observation learning the demonstration method seems generally to be more successful than the video method or chalkboard method. By contrast, the theory learning was generally more successful with either the video method or the chalkboard method.

These conclusions are only tentative and much more research would be required before they could be accepted as of general significance.

TEST	DEMONSTRATION	VIDEO	BOARD
1	1,02	1,04	0,90
2	1,16	0,88	0,92
3	0,73	0,25	0,51

Table 4.4: The % score ratios (O:T) on each test.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. SUMMARY OF THE RESEARCH

The primary purpose of this study was to determine which of the commonly used methods is the most effective method of teaching the syllabus experimental work. The fundamental reason behind this study stems from the fact that the D E T examinations question paper for the matriculation candidates contains some questions based on the experimental work. Most of the teachers fail to conduct experiments in a laboratory due to a number of constraints mentioned in chapter 1. Demonstrations, filmed experiments and chalkboard as a means of illustrating the experimental work are commonly used in the township secondary schools as alternative methods to hands-on experimental work. In the circumstances these methods have advantages over hands-on experimental work, as was discussed in chapter 2. Three experimental groups were selected from Standard 8 pupils from a secondary school in the East Rand.

Pupils were taught three different topics on the reactions of (i) metals and oxygen, (ii) metals and water and (iii) non-metals and oxygen. After each topic had been taught, pupils wrote a test. The significance of the difference between the mean scores of the groups was established by applying the t-test (two tailed test), using the generally accepted 5% and 1% levels of significance. After the analysis of the results one could not say with certainty which of these methods under study is consistently the most effective method.
There were however indications that the demonstration method is the most effective for teaching the observations, but the least effective for teaching background theory.

5.2. RESEARCH CONCLUSIONS

This study concludes that the pupils learn differently when they are exposed to different teaching methods. However, their learning is influenced by many things other than teaching methods. Their learning can be influenced by the subject matter taught and the interest they have in it or the manner of presentation or pupils' participation in class or other external factors. It can be seen in Table 4.1, that pupils in Group A, performed better compared to the other groups on all occasions. It is probably because this group was more actively involved during the lesson.

According to the t-test, the null hypothesis may be accepted at 1% level of significance, which implies that there is no significant difference in average marks irrespective of the method used. Even at the 5% level of significance there was no consistent indication of the superiority of any one method.

In this study it was found that different experimental methods fulfilled different aims and objectives of experimental work to some degree. The video method resulted in a negative attitude, which is not the actual objective of experimental work. This is in agreement with Carpenter and Greenhills' finding that the pupils feel that less is learned from the filmed instruction than from the lecture method (9). Ben-Zvi and her co-workers (10) in their study on the effectiveness of filmed experiments as an alternative to the hands-on experimental work, revealed that, the attainment of cognitive skills was not significantly affected by which approach was used. The video method was largely recommended for the teaching of manipulative skills more than any other objectives of experimental work. In this study, however, the learning (recall aspects) of some prescribed science concepts was tested. In this respect the video method is not the best method to be employed since pupils' positive attitude and interest, which are prerequisites of learning, are not developed by this method. Nevertheless pupils achieved better on theory questions after exposure to video teaching, than they did ater demonstrations !

As far as the chalkboard method is concerned one cannot tell with confidence whether interest was stimulated or positive attitudes were developed. It is not easy to note any change since they are most acquainted to this method.

With the demonstration method, the pupils seemed motivated and their interest was stimulated. The results could have been better if it had been employed to fill the supportive role - that of confirming the theory which had already been taught - as most educationists (21) recommend. On the basis of the researcher's observation most of the pupils tested preferred teacher demonstrations because they can be allowed to ask questions during the session and teachers might provide them with answers. That can lead to meaningful learning.

5.3. RECOMMENDATIONS

As the result of the study, the recommendations for further research are as follows;

1. Further research concerning the most effective method of teaching experimental work in the secondary schools should be done as there is a need of a method that will enable the teachers to achieve the aims and objectives of the experimental work.

2. There is a need of further study in this area using subjects coming from different schools and different townships. Different teachers could also be involved to determine how variation of teachers influences the learning of pupils.

3. More research is needed to discover ways by which one can minimize the disadvantages of each method.

4. Further research into the best ways of using video presentation should be done. For example, how can one use video to develop interest and a positive attitude in pupils that will foster meaningful learning.

VI REFERENCES

1. Head J, 1982. "What can psychology contribute to science education ?", School Science Review, (63), no. 222, pp. 631-641.
2. Connell L, 1971. "Demonstrations and individual practical work in science.", School Science Review, (52), no. 180, pp. 692-702.
3. MacFarlarne L R, 1982. Subject didactics: Physical Science (H.E.D)., Pretoria: UNISA.
4. Collusi G M, 1980. Practical work in teaching in S.A. schools for White pupils, unpublished MEd. Dissertation, Johannesburg: University of the Witwatersrand.
5. Toothacker W S, 1983. "A critical look at introductory laboratory instruction.", American Journal of Physics, (51), no. 6, pp. 516-520.
6. Woolnough B & Allsop T, 1985. Practical work in science., Cambridge; University Press.
7. Papenfus J N, 1981. "Practical work in science: The development of learning skills.", Spectrum 19 (3);pp. 61-63.
8. Stone T J, 1972. "Down with labs.", Education in Chemistry, (9); p. 204.

9. Ben-Zvi R, Hofstein A & Samuel D, 1976. "The attitude of high school students towards the use of filmed experiments.", Journal of Chemical Education, (53), no. 9, pp. 575-577.

10. Ben-Zvi R, Hofstein A & Samuel D, 1976. "The effectiveness of filmed experiment in high school chemical education.", Journal of Chemical Education, (53), no. 8, pp. 518-520.

11. Hofstein A & Lunetta V N, 1982. "The role of the laboratory in science teaching: neglected aspects of research.", Review of Educational Research, (52), no. 3, pp. 201-213.

12. Tuckman B W, 1978. Conducting Educational Research. 2nd ed. New York: Harcourt Brace Jovanovich, Inc.

13. Kerlinger F N, 1986. Foundation of Behavioural Research. 3rd ed. New York: Holt, Rinehart & Winston.

14. Morris L L & Fitz-Gibbon C T, 1983. How to measure achievement. London: Sage Publishers Inc.

15. Bradley R L, 1968. "Is the science laboratory necessary for the general science courses?", Science Education, (52); no. 1, pp. 58-60.

16. Beatty J W & Woolnough B E, 1982. "Why do practical work in 11-13 science ?", School Science Review, (63), no. 225,

pp. 768-769.

17. Hodson D, 1990. "A critical look at practical work in school science.", <u>School Science Review</u>, (70), no. 236, p. 34.

18. Read F H, 1969. " New techniques for the teaching of practical physics.", <u>Physics Education</u>, (4); p. 77.

19. Kruglak H, 1952. "Experimental outcomes of laboratory instruction in elementary college physics.", <u>American Journal of Physics</u>, (20); pp. 136-137.

20. Lock R, 1988. "A history of practical work in school science and its assessment, 1860-1986.", <u>School Science Review</u>, (69), no. 250, pp. 115-119.

21. Johnstone A H & Gunning D J, 1976. "Practical work in the Scottish O-grade.", <u>Education in Chemistry</u>, (13); pp. 12-14.

22. Barger T M, 1935. "Effectiveness of the individual laboratory method in science.", <u>Journal of chemical Education</u>, (12); pp. 229-231.

23. Naik K C, 1973. <u>Some aspects of Physical Science teaching at matriculation level in Indian high schools in the Transvaal</u>. Unpublished BEd Dissertation. Johannesburg: University of the Witwatersrand.

24. Slabough W H, 1959. "Trends in instruction of chemistry by films and television.", Journal of Chemical Education, (36); pp. 588-560.

25. Watson F G, 1963. Handbook of research on teaching. (editor N.L. Gage). Chicago; Rand McNally.

26. Lynch P P, 1987. "Laboratory work in universities: structures and strategies still largely unexplored.", Australian Science Teachers Journal, (32), no. 4, pp. 31-37.

27. Kerr J F, 1963. Practical work in school science. Leicester: Leicester University Press.

28. Lynch P P, 1986. "Towards a policy for assessment of school practical work.", Imstus News, Stellenbosch, no. 13; pp. 4-6.

29. Arnold W & James J, 1991. "Assessment ... can be fun! School Science Review, (72), no. 261, pp. 132-134.

30 King W & Brathwaite W, 1991. "School-based assessment in science - Carribean perspective."., School Science Review, (72), no.261, pp. 127-131.

31. Brink B du P & Jones R C, 1985. Physical Science Std 8., Cape Town: Juta & Co..

32. Brits G H F, Elloff G A & Botha N P J, 1986. Complete

Physical Science Std 8., Johannesburg: Educum Publishers.

33. Ary D, Jacobs L C & Razavieh A, 1990. Introduction to Research in Education., New York: Holt, Rinehart & Winston Inc..

34. Moodley T K 1972. A critical survey of practical work in biology at senior secondary level in Indian High school in Natal. Unpublished MEd Dissertation. Pretoria: UNISA.

35. Mulder J C 1982. Statistical techniques in education., Pretoria: Haum.

36. O'Neill T 1992. A guide to building high-school science labs. The centre for the advancement of science and mathematics education: University of Natal-Durban.

37. Mundangepfupfu R M 1986. Economies in the provision of facilities for teaching secondary school science, Economic Development Institute, Education and Training Division, United Nations.

APPENDIX A

EXPERIMENT 1 - DEMONSTRATION METHOD

TITLE: REACTION OF METALS AND OXYGEN

APPARATUS: Test-tube, glasswool and burners

PROCEDURE

1. Put approximately two grams of potassium permanganate in a test tube.
2. Make a plug of glasswool and press it down the tube to just above the permanganate. Place some lithium, about the size of a pea, into the same pyrex test-tube and place a second plug of glasswool above it. Heat the lithium and potassium permanganate simultaneously with the bunsen burner Heat lithium until it melts and ignites. As the potassium permanganate is heated, it releases oxygen which comes into contact with molten lithium.
3. Scrape the product that was formed into a clean test tube. Add 10 ml of water and a few drops of universal indicator or dip a litmus paper into a solution.
4. Repeat this experiment using sodium, potassium and calcium.

5. Repeat this experiment using approximately 1 g of magnesium, iron and copper filings.

ACTIVITIES AND OBJECTIVES AS WRITTEN ON THE CHALKBOARD.

1. Observe what happens when a metal is heated.
2. Arrange metals in order of decreasing activity.
3. Are solutions of reaction products acidic or basic ?

APPENDIX B

EXPERIMENT 2 - DEMONSTRATION METHOD

TITLE: REACTION OF METALS AND WATER

APPARATUS: Test-tube, bunsen burner and beaker.

PROCEDURE A:

1. Half fill seven test-tubes with cold water.
2. Place small pieces of metals (Li, Na, K, Mg, Ca, Fe, Cu) into a test-tube in a given order. Hold a burning match to the mouth of each tube.

PROCEDURE B:

3. Heat the water while placing in it Ca, Mg, Cu and Fe respectively.
4. Hold the burning march on the mouth of the test-tube.

PROCEDURE C:

5. Place moist glasswool on the bottom of the test-tube and a piece of Mg, Fe or Cu in the middle of the same test-tube. Heat Mg, Cu or Fe and glasswool simultaneously in the test

tube. Steam comes into contact with the heated metal. When the gas is given off, the collecting tube will be filled with it and bubbles will be observed in water.

ACTIVITIES AND OBJECTIVES AS WRITTEN ON THE CHALKBOARD.

1. Observe what happens when metals react with water.
2. State or name metals that can react with cold water.
3. Order them according to increasing activity.
4. Name metals that react with hot water.
5. Arrange metals in (4) in order of increasing activity.
6. Name the metals that react with steam.

APPENDIX C

EXPERIMENT 3 - DEMONSTRATION METHOD

TITLE: REACTION OF NON-METALS AND OXYGEN

APPARATUS: Gas jar, deflagrating spoon and bunsen burner

PROCEDURE:

1. Put a piece of phosphorus in a deflagrating spoon and lower it into a gas jar filled with oxygen and 10 ml of water.
2. Repeat this experiment with pieces of sulphur and carbon by first heating them in separate deflagrating spoons until they ignite or glow and then lowering them in separate oxygen-filled gas jars.

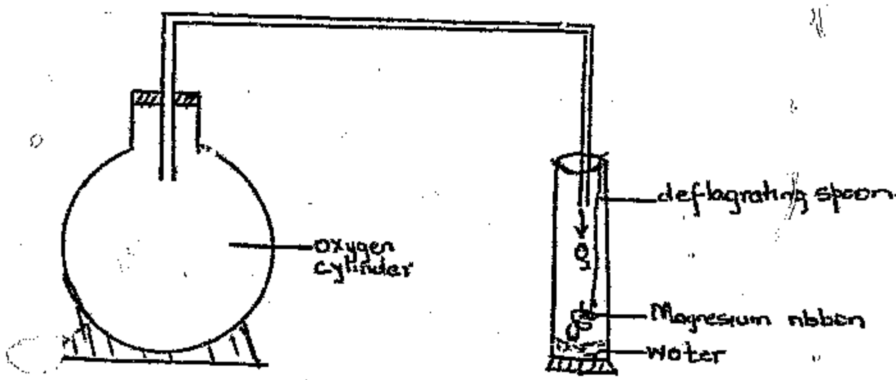
ACTIVITIES AND OBJECTIVES AS WRITTEN ON THE CHALKBOARD.

1. Observe what is happening in each instance.
2. Arrange non-metals in order of increasing activity with oxygen.
3. Check whether the oxide is acidic or basic.

APPENDIX D

TEST 1 - REACTION OF METALS AND OXYGEN

A magnesium ribbon was heated in the presence of oxygen supplied from the cylinder, and the product formed was mixed with water in a gas jar.



1. What is observed when magnesium is heated in a gas jar of oxygen ? (2)
2. What happens to the red litmus paper when dipped into the solution in a jar ? (2)

3. Write a balanced reaction equation when magnesium reacts with oxygen. (5)

4. What is the name of the product ? (2)

5. Write a balanced reaction equation of the product in (3) reacting with water. (3)

6. Consider these metals copper, magnesium, calcium and iron.

 (i) Arrange these metals in order of increasing activity with oxygen. (4)

 (ii) Is the oxide of calcium acidic or basic ? (2)

7. Write out the formula of potassium oxide. (2)   TOTAL [22]

SOLUTION

1. Magnesium reacts easily and forms a white product.

2. It turns from red to blue.

3. $2\ Mg + O_2 \text{ -----> } 2\ MgO$

4. Magnesium oxide.

5. $MgO + H_2O \text{ -----> } Mg(OH)_2$

6. (i) Copper < iron < magnesium < calcium.

 (ii) Basic

7. K_2O

APPENDIX E

TEST 2 - REACTION OF METALS WITH WATER.

1. Consider these metals: sodium, magnesium, calcium and iron.
 (a) Name the metal or metals that can react with:
 (i) cold water only (ii) hot water only (iii) steam only (6)
 (b) Which metal reacts most vigorously with water ? (2)
 (c) Which metal is least reactive with water ? (2)
2. Write a balanced reaction equation of calcium and water. (5)
3. How do you test a gas that is liberated when metals react with water ? (3)
4. Name the gas liberated in (3). (2)
5. Arrange the hydroxides of calcium, magnesium and sodium in order of increasing pH values. (3)

TOTAL= 23

SOLUTION

1. (a) (i) sodium and calcium
 (ii) magnesium

(iii) iron

(b) sodium

(c) iron

2. $Ca + 2 H_2O \longrightarrow Ca(OH)_2 + H_2$

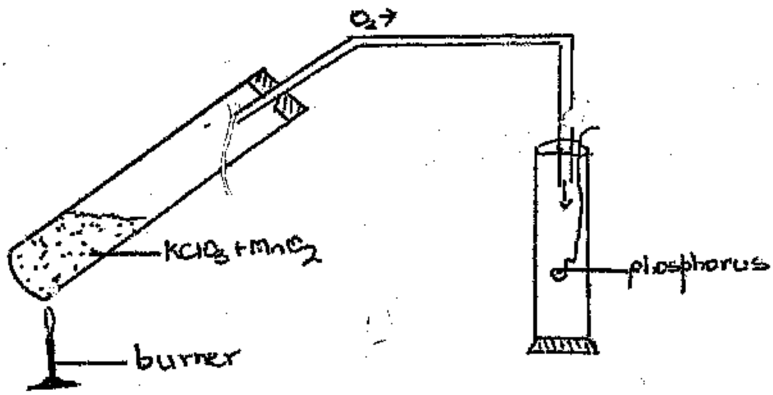
3. By bringing a burning stick or match to the mouth of reaction vessel: if there is an explosive sound a gas is released.

4. Hydrogen.

5. Magnesium < calcium < sodium.

APPENDIX F

TEST 3 - REACTION OF NON-METALS AND OXYGEN



1. Write a balanced reaction equation of phosphorus and oxygen. (6)
2. What is the name of the product in (1) ? (2)
3. Is the oxide acidic or basic ? (1)
4. What can be done to confirm your answer in (3) ? (4)
5. Why is it necessary to keep white phosphorus under water?(2)

6. Arrange the following elements: phosphorus, carbon and sulphur in order of increasing activity with oxygen. (3)
7. What is the colour of the flame formed when oxygen reacts with (i) carbon
   (ii) phosphorus (4)

TOTAL [22]

SOLUTION

1. 4 P + 5 O_2 ----> $2P_2O_5$
2. Phosphorus pentoxide
3. Acidic
4. Dip a blue litmus paper into an aqueous solution of the oxide and when it changes to be pinkish colour it means that the solution is acidic.
5. It reacts very fast when it comes into contact with oxygen.
6. Carbon < sulphur < phosphorus.
7. (i) red (ii) bright (white vapour)

APPENDIX G

RESULTS FOR TEST 1 (Metals and oxygen)

PUPIL No.	GROUP A DEMONSTRATION	GROUP C VIDEO	GROUP B BOARD
1.	12	13	12
2.	16	10	6
3.	12	3	9
4.	8	8	13
5.	18	2	14
6.	7	10	8
7.	7	8	11
8.	5	4	4
9.	8	5	7
10.	14	3	8
11.	6	4	9
12.	8	5	9
13.	8	8	2
14.	9	8	12
$\sum X$	138	91	124

APPENDIX H

RESULTS FOR TEST 2 (Metals and water)

PUPIL No.	GROUP B DEMONSTRATION	GROUP A VIDEO	GROUP C BOARD
1.	15	20	18
2.	20	19	13
3.	13	20	12
4.	12	15	20
5.	15	22	20
6.	6	8	14
7.	15	12	8
8.	15	17	11
9.	12	13	6
10.	8	15	8
11.	7	13	11
12.	9	14	4
13.	9	1	4
14.	12	7	5
$\sum X$	168	196	154

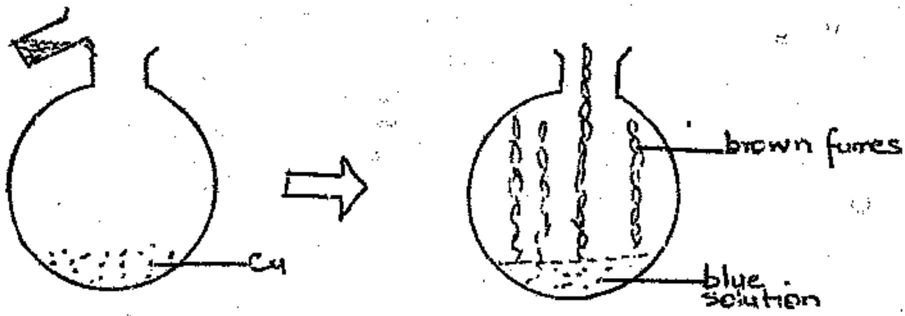
APPENDIX I

RESULTS FOR TEST 3 (Non-metals and oxygen)

PUPIL No.	GROUP C DEMONSTRATION	GROUP B VIDEO	GROUP A BOARD
1.	17	17	9
2.	14	10	6
3.	1	7	17
4.	15	2	12
5.	9	7	17
6.	3	8	9
7.	9	9	11
8.	8	7	16
9.	8	6	14
10.	5	7	9
11.	6	7	9
12.	7	7	13
13.	9	2	10
14.	2	8	9
$\sum X$	113	104	161

APPENDIX J

1. When a concentrated nitric acid is poured into a flask containing a few copper turnings a blue-green solution forms in the flask and brown fumes are given off.



(a) What substance causes the blue-green colour in the flask ?

(b) What is the brown fuming gas that is given off ? (2)

If a more dilute solution of nitric acid is added to the flask, instead of concentrated acid, a colourless gas is given off and brown fumes only appear at the mouth of the flask.

(c) Write down balanced chemical equations to show:

(i) the reaction which forms a colourless gas. (4)

(ii) why brown fumes form at the mouth of the flask ? (3)

(March 1981, second paper)

2. Chlorine gas can be prepared in the laboratory by reacting concentrated hydrochloric acid with manganese dioxide.

(a) Write down the balanced reaction equation for this reaction. (4)

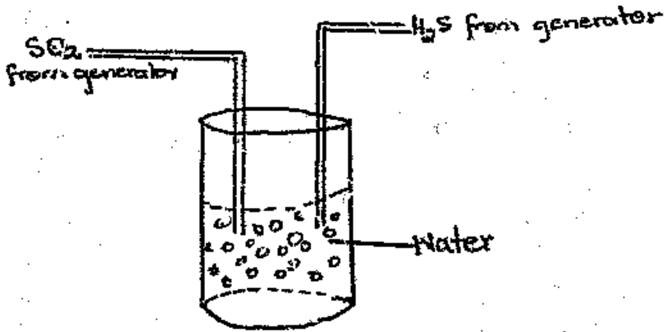
(b) Sketch the apparatus, as set up, that one should use to prepare and collect a small amount of the gas. (5)

(c) Why must this experiment be done in a fume cupboard ? (2)

(d) What is the colour of the gas that is collected ? (2)

(June 1991, second paper)

3.



In this experiment H_2S and SO_2 are bubbled simultaneously through water. A precipitate is formed.

3.1 What will be observed in the beaker ? What is the precipitate that is formed ? (2)

3.2 Name the oxidising agent. (2)

3.3 Which substance is reduced ? (2)

3.4 Give a balanced equation for the reaction that occurs. (7)

APPENDIX K

TEST 1 Metals and oxygen

PUPIL No.	GROUP A DEMONSTRATION		GROUP C VIDEO		GROUP B BOARD	
	O	T	O	T	O	T
Max Marks	8	14	8	14	8	14
1.	2	10	5	8	5	7
2.	3	13	4	6	1	5
3.	5	7	2	1	2	7
4.	5	3	3	5	3	10
5.	7	11	1	1	5	9
6.	3	4	1	9	2	6
7.	3	4	5	3	4	7
8.	3	2	1	3	2	2
9.	3	5	2	3	4	3
10.	5	9	0	3	2	6
11.	3	3	1	3	2	7
12.	3	5	1	4	5	4
13.	3	5	4	4	2	0
14.	3	6	4	4	3	8
Σx	51	87	34	57	42	82
$\overline{X}$	3,64	6,21	2,43	4,07	3,0	5,86
% $\overline{X}$	45,5	44,4	30,4	29,1	37,5	41.8

APPENDIX L

TEST 2 Metal and water

PUPIL No.	GROUP B DEMONSTRATION		GROUP A VIDEO		GROUP C BOARD	
	O	T	O	T	O	T
Max Marks	12	11	12	11	12	11
1.	9	6	9	11	8	10
2.	10	10	11	8	9	4
3.	8	5	10	10	6	6
4.	7	5	11	4	11	9
5.	8	7	12	10	10	10
6.	3	3	5	3	6	8
7.	8	7	5	7	6	2
8.	8	7	8	9	5	6
9.	3	9	6	7	2	4
10.	4	4	5	10	4	4
11.	4	3	6	7	4	7
12.	7	2	5	9	2	2
13.	7	2	0	1	2	2
14.	8	4	3	4	2	3
Σx	94	74	96	100	77	77
$\overline{X}$	6,71	5,29	6,86	7,14	5,5	5,5
% $\overline{X}$	55,9	48,1	57,1	64,9	45,8	50,0

APPENDIX M

TEST 3 Non-metals and oxygen

PUPIL	GROUP C		GROUP B		GROUP A	
No.	DEMONSTRATION		VIDEO		BOARD	
	O	T	O	T	O	T
Max Marks	5	17	[illegible]	17	5	17
1.	3	14	1	16	2	7
2.	1	13	0	10	1	5
3.	0	1	1	6	4	13
4.	3	12	0	2	0	12
5.	5	4	0	7	4	13
6.	0	3	1	7	1	8
7.	1	8	0	9	2	
8.	1	7	0	7	1	15
9.	1	7	1	5	1	13
10.	1	4	0	7	1	8
11.	1	5	1	6	1	8
12.	1	6	0	7	1	12
13.	1	8	1	1	1	9
14.	1	1	1	7	1	8
Σx	20	93	7	97	21	140
$\overline{X}$	1,43	6,64	0,5	6,93	1,50	10,00
% $\overline{X}$	28,6	39,1	10,0	40,8	30,0	58,8