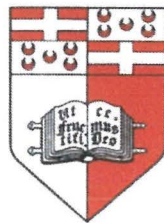


# **A Cross-Sectional Study of Students' Perceptions of Practical Work in Science Education**

Marissa R. Galea



A Dissertation Presented to the Faculty of Education  
in Part Fulfilment of the Requirement for the Degree of  
Master of Education  
at the  
University of Malta

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# **ABSTRACT**

Marissa R. Galea

## **A Cross-Sectional Study of Students' Perceptions of Practical Work in Science Education**

This study aimed to investigate students' perceptions of practical work in science in a co-educational school in Malta. The study explored the issues involved in the theoretical basis, rationale and implementation of practical work. A case study strategy was employed using both quantitative and qualitative methods to achieve the objectives of the study. This took the form of a questionnaire filled by 379 senior school students (11 to 16-year-olds) and interviews with five of the students' respective teachers. The target population of the study was all the students and science teachers of the secondary school. Amongst the main findings students and teachers stated cognitive, affective and skills arguments as reasons why experiments were carried out. Students seemed to find experiments helpful in understanding the subject and performing in examinations. They mentioned a number of factors that helped them remember an experiment such as if the experiment is fun, easy and interesting. Students remarked on factors that make a good experiment such as having good quality apparatus, clear instructions and performing the experiment themselves. Overall they seemed to have a good understanding of both the aim of the experiment and what went on during an experiment. Most students in all grades believe report writing helps them understand the experiment better. Students gave recommendations for improvement such as removing or reducing the amount of report writing and having smaller groups when doing the experiment. Differences depending on gender were investigated, for example, in Grades 8 and 9 males found the practical sessions easier than their female counterparts whereas in Grades 10-12, females seemed to find practical sessions easier overall. Variations according to the grade they are in were also investigated. The results of this study include implications for science practical work within the school and recommendations for further research.

Supervisor:

Dr. Josette Farrugia

M.Ed. (Science Education)

August 2008

**PRACTICAL WORK**

**CASE STUDY**

**STUDENTS' PERCEPTIONS**

**SECONDARY EDUCATION**

**TEACHERS' PERCEPTIONS**

**SCIENCE SUBJECTS**

Dedicated to my family and my fiancé Gary,  
and to the doctors, nurses, parents and children of  
Rainbow Ward, Mater Dei  
in appreciation for their support and help.  
Your contributions have been greatly appreciated.

*Thank you for being there  
through every laugh, through every tear.  
You helped me not to be scared  
about the things that I feared.  
Thank you for the love that you have shown  
when you knew I would have blown.  
You are an important person in my life  
you've helped me deal with my strife.  
From time to time you always listened  
and when you did so your eyes always glistened.  
You never put me down  
and you always knew how to turn my frown upside down.  
Thank you for being there for me  
and letting me be who I want to be.*

Stacy Marie Arruda

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# Table of Contents

<b>Chapter 1: Introduction</b> .....	1
1.1 Introduction .....	2
1.2 Background to the Study .....	2
1.3 Rationale for the Study .....	4
1.4 Research Questions and Intentions .....	4
1.5 Significance of the Study .....	5
1.6 Methodology .....	6
1.7 Overview of the Thesis .....	6
1.8 Conclusion.....	7
<b>Chapter 2: Literature Review</b> .....	8
2.1 Introduction .....	9
2.2 What is Practical Work?.....	10
2.3 The Difference in Importance given to Practical Work .....	10
2.4 Reasons for doing Practical Work.....	10
2.5 The Aims of Practical Work.....	14
2.5.1 To Enhance the Learning of Scientific Knowledge.....	15
2.5.2 To Teach Procedures and Training in Laboratory Skills.....	15
2.5.3 To Show Students the World of Scientists and Provide Insight into Scientific Method .....	16
2.5.4 To Provide a Focus for Student-Student and Student-Tutor Interaction .....	16
2.5.5 To Motivate Students and Develop Positive Attitudes to the Subject.....	17
2.6 Alternative Ideas about Practical Work.....	17
2.6.1 Counter-Arguments concerned with the Reasons for doing Practical Work in Science.....	18
2.6.2 Counter-Arguments concerned with the Aims for doing Practical Work in Science.....	21
2.7 The need to know Students' Perceptions .....	26
2.8 Research about Students' Perceptions of Practical Work .....	27
2.9 Teachers' Perceptions of Practical Work .....	30
2.10 Assessment of Practical Work.....	33
2.11 Conclusion.....	34
<b>Chapter 3: Planning and Designing the Study</b> .....	35
3.1 Introduction .....	36

3.2 Choice of Location .....	36
3.2.1 Receiving Authorisation .....	37
3.2.2 Choice of Respondents .....	37
3.3 Choosing the Research Method.....	37
3.3.1 Qualitative and Quantitative Research .....	38
3.4 Planning the Study .....	38
3.5 Identifying the Questions to Guide the Research.....	39
3.6 Collecting Information to Answer the Questions.....	39
3.6.1 Planning and Interviewing Grade 12 Students .....	40
3.6.2 Constructing the Questionnaire .....	42
3.6.3 Piloting .....	45
3.6.4 Finalising the Questionnaire.....	46
3.6.5 Administering the Questionnaire.....	48
3.7 Preparing and Analysing Data.....	48
3.7.1 Inputting and Preparation of Data .....	48
3.7.2 Data Analysis.....	50
3.8 Teacher Interviews .....	51
3.9 Share the Findings.....	54
3.10 Conclusion.....	55
<b>Chapter 4: Presenting and Analysing the Information Gathered .....</b>	<b>56</b>
4.1 Introduction .....	57
4.2 Description of the Respondents.....	57
4.3 Importance given to Practical Work.....	61
4.4 The Reasons for doing Practical Work .....	62
4.4.1 Practical Work: An Aid for Understanding.....	64
4.4.2 Practical Work: An Aid for Performing Better in Examinations .....	66
4.5 The Effect of MATSEC on Requirements on Practical Work .....	69
4.6 Student Satisfaction with the Amount of Practical Work Done.....	70
4.7 Students' Perceptions of the Difficulty of Practical Work as they Progress	
Academically .....	75
4.8 Factors that make Experiments Enjoyable or not for Students .....	79
4.8.1 Preference of Particular Experiments .....	84
4.9 Factors that make a Good Experiment .....	87
4.10 Feeling like a Scientist .....	90
4.11 The Instructions given for Practical Work .....	95
4.11.1 Suggestions for Improvement of Instructions .....	99

4.12 Types of Practical Work done .....	100
4.12.1 Inductive or Deductive Experiments .....	100
4.12.2 Experiments Students Prefer .....	102
4.12.3 Different Types of Practical Work carried out in the School Laboratory ..	105
4.12.4 Do Students Design Experiments? .....	108
4.12.5 The Experiments Students Prefer .....	110
4.13 Grouping during Practical Work .....	114
4.14 Students' Perceptions of Report Writing.....	119
4.14.1 Report Writing: An Aid to Understanding the Experiment better.....	119
4.14.2 The Help given to write Reports .....	122
4.14.3 The Sort of Results Included .....	124
4.14.4 The Importance of the Different Parts of the Report.....	126
4.15 Marking the Report .....	133
4.16 Suggestions for Improvement .....	139
4.17 Conclusion.....	140
<b>Chapter 5: Conclusions and Some Implications .....</b>	<b>142</b>
5.1 Introduction .....	143
5.2 Major Findings of the Study.....	143
5.3 Implications and Recommendations for the School.....	150
5.4 Limitations of the Study .....	155
5.5 Recommendations for Further Research .....	156
5.6 Conclusion.....	157
References .....	159
Appendix 1 Grade 12 Interview Questions.....	174
Appendix 2 Questionnaires used for the Pilot Study .....	177
Appendix 3 Questionnaires .....	193
Appendix 4 Teacher Interviews .....	216
Appendix 5 Statistical Data.....	223
Appendix 6 Practical Handout .....	280
Appendix 7 Assessment Criteria for Science Practical Work.....	288

# List of Tables

Table 4.1: Students by Grade and Gender.....	57
Table 4.2: Subject combinations chosen by Grade (Grades 10-12).....	58
Table 4.3: Subject combinations chosen by Gender (Grades 10-12).....	59
Table 4.4: Number of students studying each subject irrespective of combination analysed by Grade and Gender (Grades 10-12).....	60
Table 4.5: Do you think experiments help you understand the subject better? (Science Students).....	65
Table 4.6: Do you think experiments help you understand the subject better? (Grades 10-12).....	65
Table 4.7: Do you feel that you will perform better in exams because you did practical work? (Science Students).....	66
Table 4.8: Do you feel that you will perform better in exams because you did practical work? (Grades 10-12).....	66
Table 4.9: The amount of practical work done between October and December for General Science students.....	71
Table 4.10: General Science students' satisfaction with the amount of practical work done.....	71
Table 4.11: The amount of practical work done between October and December divided by Subject and Grade.....	72
Table 4.12: Satisfaction with amount of practical work done divided by Subject and Grade.....	72
Table 4.13: Are the tasks given during your experiment difficult? (Science Students)..	75
Table 4.14: Are the tasks given during your experiment difficult? (Grades 10-12).....	76
Table 4.15: Does the difficulty of practical work change over the years? (Science Students).....	77
Table 4.16: If yes, in what way? (Science Students).....	78
Table 4.17: Does the difficulty of practical work change over the years? (Grades 10-12).....	78
Table 4.18: If yes, in what way? (Grades 10-12).....	78
Table 4.19: Do you enjoy practical work? (Science Students).....	79
Table 4.20: Do you enjoy practical work? (Grades 10-12).....	80
Table 4.21: Which Science subject practicals do you prefer? (Grades 10-12).....	87

Table 4.22: Do you feel like a real scientist when doing experiments? (Science Students).....	90
Table 4.23: Do you feel like a real scientist when doing experiments? (Grades 10-12).....	90
Table 4.24: Do you understand the aim when you are doing an experiment? (Science Students).....	95
Table 4.25: Do you understand what's happening during the experiment? (Science Students).....	96
Table 4.26: Do you understand the aim when you are doing an experiment? (Grades 10-12).....	96
Table 4.27: Do you understand what's happening during the experiment? (Grades 10-12).....	97
Table 4.28: Do you understand the instructions given? (Science Students) .....	99
Table 4.29: Do you understand the instructions given? (Grades 10-12).....	99
Table 4.30: Which order do you think would allow you to learn better, covering theory and then doing the experiment or vice versa? (Science Students) .....	100
Table 4.31: Which order do you think would allow you to learn better, covering theory and then doing the experiment or vice versa? (Grades 10-12).....	101
Table 4.32: Do you ever have experiments where you design the experiment yourself without the help of instructions? (Science Students) .....	108
Table 4.33: Do you ever have experiments where you design the experiment yourself without the help of instructions? (Grades 10-12).....	109
Table 4.34: Which type of practical work would you prefer? (Science Students).....	111
Table 4.35: Which type of practical work would you prefer? (Grades 10-12) .....	111
Table 4.36: Should the practical work be carried out individually, in pairs or in groups? (Science Students) .....	115
Table 4.37: Should the practical work be carried out individually, in pairs or in groups? (Grades 10-12).....	115
Table 4.38: Does report writing help you understand the experiment better? (Science Students).....	120
Table 4.39: Does report writing help you understand the experiment better? (Grades 10-12).....	120
Table 4.40: What sort of help are you given to write a report? (Science Students).....	122
Table 4.41: What sort of help are you given to write a report? (Grades 10-12) .....	122
Table 4.42: In the report what kind of results do you include? (Science Students).....	125
Table 4.43: In the report what kind of results do you include? (Grades 10-12).....	125

Table 4.44: Which part of the report do you think is the most important? (Science Students).....	126
Table 4.45: Which part of the report do you think is the most important? (Grades 10-12).....	127
Table 4.46: Which part of the report do you think is the least important? (Science Students).....	128
Table 4.47: Which part of the report do you think is the least important? (Grades 10-12).....	128
Table 4.48: On average how many marks do you usually obtain for your report? (Science Students).....	130
Table 4.49: On average how many marks do you usually obtain for your report? (Grades 10-12).....	130
Table 4.50: Should each part of the report be equally important when calculating the final mark? (Science Students).....	131
Table 4.51: Should each part of the report be equally important when calculating the final mark? (Grades 10-12).....	131
Table 4.52: Should marks be given for reports? (Science Students).....	133
Table 4.53: Should marks be given for reports? (Grades 10-12).....	134
Table 4.54: Do you think marks should be given for the actual practical besides the report? (Science Students).....	136
Table 4.55: Do you think marks should be given for the actual practical besides the report? (Grades 10-12).....	136
Table 4.56: Should the average marks for reports be part of the annual examination mark? (Science Students).....	138
Table 4.57: Should the average marks for reports be part of the annual examination mark? (Grades 10-12).....	138

# List of Figures

Figure 3.1: Close-ended question .....	44
Figure 3.2: Open-ended question.....	44
Figure 3.3: Question 41 of the Grade 8 questionnaire .....	46
Figure 3.4: Question 41 of the Grade 9 questionnaire.....	46
Figure 3.5: Question 6 of the Grade 8 questionnaire.....	47
Figure 3.6: Question 6 of the Grade 10-12 questionnaire.....	47
Figure 3.7: Question 18 with the 'other' option.....	47
Figure 3.8: List of queries and Chemistry by Grade query .....	49
Figure 3.9: The Database .....	50
Figure 3.10: Spreadsheet showing data .....	51
Figure 3.11: Qualitative data for question 43 .....	52
Figure 3.12: Example of the main question and prompts during the interview.....	53
Figure 4.1: Number of students by Grade and Gender.....	58
Figure 4.2: Percentage of Subject combinations chosen by Grade.....	59
Figure 4.3: Subject combinations chosen by Gender (Grades 10-12) .....	60
Figure 4.4: Percentage of responses by Subject .....	61
Figure 4.5: Amount of practical work per Grade.....	70
Figure 4.6: Satisfaction with the amount of practical work done in the three sciences.....	73
Figure 4.7: Satisfaction with the amount of practical work done by Gender in Biology .....	73
Figure 4.8: Satisfaction with the amount of practical work done by Gender in Chemistry .....	74
Figure 4.9: Satisfaction with the amount of practical work done by Gender in Physics.....	75
Figure 4.10: Perception of difficulty by Subject.....	76
Figure 4.11: Perception of difficulty by Gender .....	77
Figure 4.12: Level of enjoyment of practical work by Grade .....	80
Figure 4.13: Level of enjoyment of practical work by Subject .....	81
Figure 4.14: The experiment preference of Grade 8 students.....	85
Figure 4.15: The experiment preference of Grade 9 students.....	86
Figure 4.16: Percentage of students who feel like real scientists when doing experiments by Gender.....	91

Figure 4.17: Percentage distribution of types of instructions given to students by Subject .....	97
Figure 4.18: Percentage of students who had to design some of the experiments themselves by Subject .....	109
Figure 4.19: Which type of practical work would students prefer by Grade.....	112
Figure 4.20: Preferred method of carrying out experiments (All Students) .....	115
Figure 4.21: Percentage of students who thought report writing helped them understand the experiment better by Grade.....	119
Figure 4.22: Percentage of Students who thought report writing helped them understand the experiment better (Grades 10-12) .....	121
Figure 4.23: Type of help given to write reports by subject.....	123
Figure 4.24: Part of the report deemed most important by students (Grades 10-12)....	127
Figure 4.25: Part of the report deemed least important by students (Grades 10-12)....	129
Figure 4.26: Percentage of students who feel each part of the report is equally important when calculating the final mark by Grade .....	132
Figure 4.27: Percentage of Students who think marks should be given for reports by Grade and Subject .....	134
Figure 4.28: Percentage of Students who think marks should be given for the actual practical besides the report by Grade and Subject .....	137
Figure 4.29: Percentage of Students who think average marks for reports should be part of the annual examination mark by Grade and Subject .....	138

**Chapter 1**  
Introduction

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## 1.1 Introduction

This study focuses on students' perceptions of practical work. Interest in this area arose as the school in which I work in gives a lot of importance to the practical side of science. I was given responsibility from the beginning of my teaching career for planning and conducting practical sessions and was also later involved in the construction of the Grade 8 and 9 General Science syllabi for the school, in which practical work plays a major role. This experience with practical work piqued the interest on my part as to what the students could tell us about the quality of the practical work being carried out and what they learnt from it. Seeing that as a department, my colleagues and I are always concerned with improving the quality and safety of practical work, which inevitably leads to constant requests for higher budgets to be invested in this area, the input of the students could help in ensuring that students gain the maximum benefits possible from the experience.

Personally, having conducted experiments with students from Grade 8 right up to second year sixth form, I believe students enjoy practical work. I am convinced that they learn a lot both from the actual experiment and from reflecting on the work when writing reports. I also believe that practical work increases students' interest in the subject and encourages them to take the science subject further. Therefore, personally I feel that it is well worth the money, effort and time. Despite my impression about students and practicals, I have always been curious as to whether the students themselves believe they benefit from the practical experience. This drew my interest in conducting this study concerning students' perceptions of practical work.

## 1.2 Background to the Study

The study concerns students' perceptions of practical work, also referred to as practicals and experiments. This study recognises that practical work is not a single entity but indicates:

*“all those teaching and learning activities in science which involve students at some point in handling or observing the objects or materials they are studying.”*

(Millar, Le Marechal, and Tiberghien, 1999, p.36)

Or, as Jenkins (1999) describes, as being about devising and planning experiments, about creativity, imagination, success, failure, collaboration, technique, disappointment and about persistence. It is about questioning what to measure, solving problems about how to measure it and evaluating its results. As Leach and Paulsen (1999) wrote:

*“It is generally assumed that practical work contributes substantially to conceptual learning and to the attainment of skills associated with ‘the methods of science’.”*

(p.8)

Wellington (2002) recognised that the science laboratory has always been regarded as the place where students should learn the process of doing science.

In Malta, the importance of practicals was formally recognised in 1994 upon the introduction of practicals as a course work component in Secondary Education Certificate (SEC) examinations as quoted below:

*“This syllabus places much emphasis on understanding biological principles and the techniques for studying them rather than on knowledge of descriptive detail and technical terms. In fact, the syllabus implies that candidates will spend more time on practical work which will aid understanding than on learning to recall biological facts. It is expected that candidates will be familiar with the skills necessary for practical work. This is why, at various sections of the syllabus, practical work is indicated as an integral part of the course.”*

(Biology SEC syllabus, 2004, p.19)

*“Chemistry is an experimental science and the importance of including practical work in the teaching programme cannot be over emphasised. While a practical paper will not be set, it is nevertheless expected that students taking the examination have had direct experience of the laboratory and have carried out a reasonable number of experimental investigations. Practical experience in chemistry will be assessed on the basis of a prescribed number of written laboratory reports which are to be submitted to the examiners for evaluation.”*

(Chemistry SEC syllabus, 2004, p. 51)

*“The syllabus is not intended to be regarded as a framework for teaching the subject. However candidates are expected to have practical experience in carrying out the investigations and experiments that are marked with an asterisk in the syllabus. Specific questions would also be set to test the application of physical principles to practical situations.”*

(Physics SEC syllabus, 2004, p.185)

Though there is apparent agreement on the need for practicals, there is no consensus on the pedagogical basis for practicals or the relative importance of the educational objectives of the practicals and as a result a number of researchers (for example Hodson, 1990; Osborne, 1998; Wellington, 1998; Hodson, 2003; Bennett, 2005) have questioned the reasons given for doing practical work.

The school under study is a co-educational independent school in Malta, which at the time of the study had a student population (senior school) of 379. The senior sector has five grades. In Grade 8 (11/12-years-old) and 9 (12/13-years-old), students study General Science, then from Grade 10 (13-16-year-olds) onwards students choose to study one, two or three of the science subjects: Biology, Chemistry and Physics.

### **1.3 Rationale for the Study**

Inconsistencies exist in the theoretical foundation, rationale, and implementation of practicals in secondary schools. While there is consensus amongst most scientists and science educators that practical exercises are an indispensable part of science education, there is a lack of clarity and agreement as to what students gain from them.

The aim of this research is to clarify our understanding of practicals and investigate the reasons and aims for doing it. It questions whether practicals are the most effective way to teach science and then gives grounds for why some of the answers may be found in investigating students' perceptions of practicals. The data collected examine students' perceptions of practicals and probe the teachers' perceptions of practicals to try to achieve a more global picture.

### **1.4 Research Questions and Intentions**

The central research aims involved the elucidation of opinions from secondary school students aged 11-16 regarding the laboratory experience in general, the perceptions of the purpose and nature of practical work and report writing, desired changes in the laboratory work, and insight to how they perceive the current assessment of practical work.

The research questions guiding this study are:

1. Do students' perceptions of practicals differ as they progress academically? How do students' perceptions of practicals differ as they progress academically?
2. Are students satisfied with the number of practicals done?
3. What do students think are the factors that make a 'good experiment'?
4. How are students given instructions and how can these be improved?
5. What do students think the purpose of report writing is, and do they think that the marking scheme is fair?
6. Which are the things that make experiments enjoyable or not for students?
7. Do students feel like a real scientist when doing experiments?
8. How do students think experiments can be improved?

This research was followed with questions to secondary school teachers regarding their laboratory experience in general, their perceptions of the purpose and nature of the laboratory work, desired changes in the laboratory work, and the actual and desired occurrence of particular elements representing exemplary practice in laboratory teaching.

Questions guiding this endeavour are listed below:

1. What goals do the teachers of this school have for the laboratory experience?
2. What changes would the teachers suggest with respect to the laboratory work?
3. Do teachers' perceptions about practical work match those of students?

## **1.5 Significance of the Study**

This study is of significance to science educators especially those of the particular school under study as it brings to light how the students perceive the practicals presented to them and illustrates whether they are found effective or not. Thus, this dissertation will be useful to the science educators involved to evaluate their science programmes.

Moreover, given that practicals require a large allocation of resources in terms of time, equipment, laboratories and specialised science educators, it is important that there is clarity and consensus about the theoretical basis, rationale and implementation of practicals in secondary science.

This study suggests how practicals can be improved. It will provide important information to other teachers in other schools who will recognise similarities to their situation in view of the practices described.

## **1.6 Methodology**

The research strategy employed was that of a case study. This was chosen because the study was aimed at studying perceptions of students of a particular school; it was not aimed at generalising to all schools. In the study, both quantitative and qualitative data were collected. Background research was done about the literature available on student perceptions of practicals (Chapter 2, *Literature Review*). Questionnaires were chosen as a research technique to collect the data from students. Following this, the students' respective teachers were interviewed to obtain further insight into how students perceive practicals (described in more detail in Chapter 3, *Planning and Designing the Study*).

## **1.7 Overview of the Thesis**

The thesis consists of five chapters, references and several appendices.

**Chapter 1**, *Introduction*, outlines the intentions and ramifications of the study.

**Chapter 2**, *Literature Review*, looks at some of the literature available about practicals and students' and teachers' perceptions of practicals.

**Chapter 3**, *Planning and Designing the Study*, describes the strategies and techniques employed to collect the necessary data.

**Chapter 4**, *Presenting and Analysing the Information Gathered*, includes presentation, analysis and discussion of the data collected and its interpretation to answer the research questions.

**Chapter 5**, *Conclusion and some Implications*, includes the conclusions drawn from the research and draws on possible implications that arise from the study.

## **1.8 Conclusion**

This chapter gave a general overview of the dissertation. The next chapter, Chapter 2 reviews the literature available about the area. It focuses on some of the research done both locally and abroad in relation to students' perceptions of practicals.

## **Chapter 2**

### Literature Review

---

## 2.1 Introduction

Practical work is often included in science teaching because it is thought to help students understand science better. This is because hands-on, minds-on activities help students learn recognised theoretical discourses and practices of science (Wallace and Loudén, 2002). On the other hand, some literature suggests that practicals are burdened with too many responsibilities and some alternative ways to teach science could be more effective. Hodson (1990) for one argues that the claims about the value of traditional laboratory activities are largely unexamined and constitute a ‘powerful, myth-making rhetoric’ (p.34). For this reason, obtaining students’ perceptions regarding practicals may help clarify whether practicals are as effective a teaching aid as one would hope.

This study concerns studying students’ perceptions about practicals. The word perception (from Latin *percipere*), refers to the process by which one acquires, interprets, selects, and organises sensory information when receiving, collecting, taking possession and apprehending with the mind or senses (Soanes and Hawker, 2005). Studying students’ perceptions on practicals is important as they are reflected in students’ attitudes to the laboratory experience. The word attitude (from Latin *aptus*) is defined within the framework of social psychology as a subjective or mental preparation for action. It defines outward and visible postures and human beliefs. Attitudes determine what each individual will see, hear, think and do. They are rooted in experience and do not become automatic routine conducts (Souza Barros and Elia, 1997). Students’ attitudes reflect the willingness of individuals to take part in certain activities, and the way they respond to persons, objects or situations. Willful participation is an important element for effective learning (Harlen, 1992).

This chapter will look at the literature dealing with the aims and reasons given to practical work. It will attempt to justify the use of students’ perceptions in this study and it will look at research from Malta and beyond on how students perceive practical work in the different science subjects. This chapter will also examine literature about teachers’ perceptions on practicals.

## 2.2 What is Practical Work?

Caamano and Corominas (2005) used the classifications proposed by Woolnough and Allsop (1985) and Gott and Duggan (1995) to classify practical work into:

- Experiences: these are perspective experiences and are more appealing when accompanied by interpretative experiences with exploratory ends on the ideas of the students;
- Illustrative experiments: these convey experimental evidence to the construction of determined concepts and illustrate laws and principles;
- Practical exercises: used to learn practical skills and processes or to experimentally verify relations between variables which are already recognised at a theoretical level;
- Investigations: these serve to learn how to plan and carry out small scale investigations to resolve theoretical or practical problems.

## 2.3 The Difference in Importance given to Practical Work

Leach and Paulsen (1999) state that the importance of practicals in science education varies immensely throughout Europe; for example, in countries such as the United Kingdom, France and the Nordic countries, practicals are commonly used as a teaching method. In Malta practicals are also given a lot of importance. However, in countries such as Italy and Greece practicals are extremely rare. Interestingly however, though the literature concerning science education emerging from countries with a tradition of practical work speaks of its limitations (e.g. Woolnough and Allsop, 1985; Jenkins, 1999 etc), countries which lack this tradition are trying to increase the amount of practicals as a teaching method in school science (Leach and Paulsen, 1999; Millar, Le Marechal and Tiberghien, 1999). Therefore, it might be worthwhile at this point to look at this literature and consider the discussion about practicals.

## 2.4 Reasons for doing Practical Work

For over a century, different authors have expressed numerous arguments in favour of practical work. Wellington (2002) mentions three arguments of this type. First, the

cognitive argument: this states that practicals improve students' comprehension of theory by illustrating it. Second, the affective argument; this maintains that practicals are motivating and exciting. And lastly, the skills argument; this states that practicals promote higher-level transferable skills like observation which are of vocational worth.

When considering the cognitive argument, Hofstein and Lunetta (2003) believe that there is a growing awareness that learning is contextualised and that learners construct knowledge by solving genuine and meaningful problems. They make the assumption that when students interact with problems that they perceive to be meaningful and connected to their experiences, and when teachers are guided by what is known about learning, students begin to develop more scientific concepts in dialogue with peer investigators. Some science educators (Lock, 1987; Roth, 1993; Hodson, 1996; Berg et al., 2003) believe that the only effective way to learn how to do science is by doing science alongside a skilled and experienced practitioner; one who can provide support, criticism and advice during the problem solving and is able to model the processes involved and invite criticism from the learner.

In support of the affective argument, Lock (1987) justifies the inclusion of practical activities solely for the intrinsic motivation that they provide. This is important because if students do not see the significance of what they are seeking to learn and cannot find stimulus and pleasure in it, very few students can persevere with work (Black, 1993). Similarly, Millar et al. (1999) believe that one of the most important reasons for doing practicals is that, students normally say that practicals are the aspect of science they enjoy most.

The third argument in favour of practicals is the skills argument. That is that practicals can help students learn and develop a range of skills. Lock (1987) believes that involvement in practicals enhances the level to which cognitive and psychomotor skills are developed. In addition he expects that these skills will be transferred to different curriculum contexts and to the everyday life of students.

Practicals also enhance students' scientific habits of mind and helps students in understanding the nature of science by introducing students to central conceptual and

procedural knowledge and skills in science (Hodson, 1993; Bybee, 2000; Hofstein and Lunetta, 2003). Roth (1993) refers to this as enculturation and believes that students learn in this way. Practicals can also lead to the fostering and development of attitudes. Lock (1987) mentions that at an individual level it can develop the confidence of students in their own capabilities or provide satisfaction due to the completion of tasks. On a wider level, the outcome of practicals should stimulate discussion which can lead to the adoption and defence of personal attitudes such as co-operative attitudes and leadership qualities.

Other researchers have given justifications for practicals which are discussed here. A few can be seen to fit with the three arguments listed above. Newton et al. (1999) believe that practical work acquaints students with scientific argumentation. Millar (2001) claims that scientific knowledge is established by a way of argumentation that leads to knowledge formation. A person can be described as understanding scientific method if they are able to propose questions about the physical world that can be investigated scientifically, if they can devise a reasonable strategy to collect the data to answer the query and if they can use the data to make sound argument in support of their conclusion as encouraged by the SEC science syllabi (2008). Therefore by doing practicals students learn that:

*“Observation and experiment are not the bedrock upon which science is built; rather they are handmaidens to the rational activity of constituting knowledge claims through argument.”*

(Newton, Driver and Osborne, 1999, p.555)

Driver (1986) adds that experimental work encourages individual initiative and imagination; this provides students with the empirical approach to problem-solving. Problem-solving in turn encourages general rational thought which is a creative process. Imagination and creativity in doing science are therefore seen as important outcomes of science education (Haigh, 2003). Woolnough and Allsop (1985) write that

*“Imaginative understanding was not a sequel to successful experiments. On the contrary, it was an essential prerequisite.”*

(pp.35-6)

Another reason given in favour of doing practicals is that most science examinations include questions about experiments (e.g. Biology, Chemistry and Physics SEC level examinations papers, 2007), as seen in the Physics syllabus (2008):

*“Paper IIA or Paper IIB will consist of five compulsory questions, two of which will test experimental skills.”*

(p.2)

It is assumed that students will fare better in this part of the examination if they have direct contact with practical work. The SEC syllabi of Biology, Chemistry and Physics give importance to practicals as seen below:

*“Chemistry is an experimental science and the importance of including practical work in the teaching programme cannot be overemphasised.”*

(Chemistry SEC syllabus 2008, p.2)

Even though a practical paper is not set, it is stated that students are expected to have carried out a reasonable number of experimental investigations. As a result, students should be able to follow instructions and select appropriate apparatus which they should be able to handle and manipulate safely, they should be able to make accurate observations and measurements, and communicate the results. Students are also expected to interpret and use experimental observations, data and results to draw conclusions and make generalisations and to be able to suggest improvements. Furthermore, the SEC syllabi request that candidates acquire skills in formulating hypotheses and to be able to design and conduct simple experiments to test the given hypotheses. They should make constructive criticism of experimental design and draw conclusions from them (Biology SEC syllabus, 2008; Chemistry SEC syllabus, 2008; Physics SEC syllabus, 2008).

Practicals are important as they may encourage students to pursue science subjects at higher levels. This was found in a study which explored the reasons for students' enrolment in post-compulsory courses in high-school Chemistry; it was found that one of the key reasons was their experience with practical exercises in the chemistry laboratory (Milner et al., 1987).

Over the years other reasons have been put forward as reasons for doing practicals like:

- it can give experience of the accurate approach demanded in some areas of scientific and technical employment (Lock, 1987);
- it helps develop cross-curricular skills such as communication, literacy, numeracy and Information and Communications Technology (ICT) (Hayward, 2003);

- it allows students to work at their own pace;
- it adds variety to the classroom activities;
- it can be devised to capture the imagination of disruptive students and therefore it reduces behavioural problems (Purnell, 1993; Swain et al. 2000).

Purnell (1993) also believes that involvement in learning is beneficial to those with learning difficulties because purposeful activities solved by team effort are educationally rewarding for students of all levels of ability. To back this, Swain et al. (2000) report that teachers in the United Kingdom use practicals as a coping strategy for working with classes of mixed ability.

The reasons for doing practicals are very much linked to the aims of practical work which are discussed in the next section.

## **2.5 The Aims of Practical Work**

Many science educators have made lists with the aims of practical work, some of which are similar to or the same as the reasons given for practical work. The following list is based on the aims proposed by Hodson (1990) and Ross and Scanlon (1995):

- To enhance the learning of scientific knowledge;
- To teach procedures and train in laboratory skills;
- To show students the world of scientists and provide insight into scientific method;
- To provide a focus for student-student and student-tutor interaction;
- To motivate students and develop positive attitudes to the subject.

Each of these aims will be described in detail in the following subsections.

### 2.5.1 To Enhance the Learning of Scientific Knowledge

Some authors (such as Woolnough and Allsop, 1985; Leach and Paulsen, 1999) have stated that practicals are done to support the theoretical concepts which form the framework for the subject matter. It might be done ‘to verify the theory’, ‘to discover the theory’ or ‘to elucidate the theory’ (Wellington, 2002), but in all cases Leach and Paulsen (1999) maintain that the theory and the practical are interwoven.

Practicals are also used where it is improbable that students observe phenomena in their everyday lives. The role here is to link the two domains of knowledge: the domain of concepts and the domain of real objects and observable things. Students need to have experiences of acting on the world (or as Woolnough and Allsop, 1985 describe they must get a ‘feel’ of phenomena (p.4)) so that they come to an understanding of the theoretical representations in order to explain it and predict its behaviour (Millar, 2004).

Osborne and Collins (2000) reported that scientific concepts were more accessible and more easily retained when supported by practical involvement, even if experiments produced incorrect results. The meaningfulness of particular tasks is greater when students have a degree of control over the planning and execution of their work rather than just listening to ideas. Practical provide this essential dimension offering students a greater sense of ownership (Swain and Dillon, 1999).

### 2.5.2 To Teach Procedures and Train in Laboratory Skills

According to Woolnough and Allsop (1985), the aim of developing scientific practical skills and techniques is fundamental in scientific education so students become “*masters of their craft*” (p.41). They continue saying that central to the skills that need to be developed are those of observation, measurement, estimation and manipulation. Furthermore, it is essential for the techniques required to plan, to execute and to interpret the results of the experiment. They also say that:

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*“the ability to manipulate, and make sense of, the data from a practical experiment, and to appreciate the extent of its reliability, can only be acquired through practice.”*

(p.42)

Through laboratory activities students can learn skills on how to design their own experiment. Bentley and Watts (1989) think that practical work should be the starting point whereby active learners initiate their own activities and take responsibility for their own learning. This implies that students have to make decisions and solve problems, they have to know how to organise themselves and how to evaluate their own and their peers' work (Gatt, 2004). Gagne (1985 as cited by Watts, 1991) suggested that through problem-solving the learner discovers the combination of previously learned rules that can be applied to achieve a solution for a novel situation. Making decisions about a solution of a problem is a creative activity and often the end product will be an expression of the student's personality (Watts, 1991).

### **2.5.3 To Show Students the World of Scientists and Provide Insight into Scientific Method**

Nurturing the habit of working as a scientist is sometimes considered the central holistic aim of practical work (Woolnough and Allsop, 1985). This revolves around the theme of students learning to act like a scientist, to acquire the scientific approach, and the belief that this can only be done by actually doing practicals the scientific way.

According to Millar (1998) this viewpoint of 'the pupil as scientist' was voiced in the Nuffield Science Teaching projects of the 1960s with their aim of making students 'a scientist for the day' (p.17). It is explicit in many school science textbooks and implicit in much of what science teachers say and do.

### **2.5.4 To Provide a Focus for Student-Student and Student-Tutor Interaction**

Properly planned practicals can develop skills of communication, interaction and cooperation (Wellington, 2002). The informal atmosphere offers opportunities for interaction and collaboration amongst students and also between students and their teacher.

This can promote positive social interactions and a healthy learning environment which is conducive to meaningful inquiry.

In addition, through collaboration, students can also come to understand the nature of an expert scientific community. The essence of a community is people interacting with each other for a purpose. The individuals' uniqueness and their capacity to work within a group are both necessary to the workings of this type of class (Osborne, 1997; Hofstein and Lunetta, 2003).

### **2.5.5 To Motivate Students and Develop Positive Attitudes to the Subject**

According to Woolnough and Allsop (1985) students justify the use of practicals in science teaching on the grounds of interest and motivation. Students come to science lessons with the expectation that they will be doing practical work and as a result if the teacher produces other non-practical strategies, they may react negatively.

Furthermore it is believed that students who have experienced a wide range of practical work will have more confidence in their ability to tackle new situations, to criticise and evaluate claims made about science in the media, and to take their education further (Hayward, 2003).

The next section will consider alternative views about practical work.

## **2.6 Alternative Ideas about Practical Work**

The aims of practical work are many; this has led some science educators (such as Roth, 1993; Osborne, 1998; Jenkins, 1999; Wellington, 2002) to question whether practical work has been unrealistically burdened with responsibilities it cannot possibly meet.

Moreover, we may be so convinced of the reasons and aims for doing practicals that we fail to look at alternative ways to teach science. Jenkins (1999) believes that practicals as taught traditionally owe too much to a discredited philosophy at the expense of other

insights, and they do not accord with the experience of young people as they encounter science in its applications in the world beyond school, as one can see here:

*“At present, it seems to me that there is a risk that laboratory work may leave students with the view that finding out about the natural world is simply a matter of doing an experiment. It is not.”*

(Jenkins, 1999, p.29)

Hodson (1991) in a strong critique of current practices of practical work wrote that

*“As practised in many schools, it is ill-conceived, confused and unproductive. For many children, what goes on in the laboratory contributes little to their learning of science or to their learning about science and its methods. Nor does it engage them in doing science in any meaningful sense. At the root of the problem is the unthinking use of laboratory work.”*

(p.176)

He argues that much practical work is done because practicals are taken for granted to be part of science lessons and with little thought being put into the purposes of the practical activity.

Osborne (1998) believes that we have developed “*cultural sclerosis*” (p.172). He states that doing science should only be a small part of learning science and that reconsideration of the reasons for doing practicals is needed. Jenkins (1999) says:

*“It is perhaps time for those who seek to justify laboratory teaching by reference to an outdated philosophy of science to recast their arguments, and thereby, their understanding of the educational functions of the laboratory, in terms of these material and intellectual practices.”*

(p.24)

The following section will look at counter arguments to the reasons and aims given in favour of doing practicals.

### **2.6.1 Counter-Arguments concerned with the Reasons for doing Practical Work in Science**

In Section 2.4 some of the reasons given for doing practicals were summarised by Wellington (2002) as the cognitive, the affective and the skills argument. For each of these

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arguments some researchers (such as Osborne, 1998; Wellington, 1998; Bennett, 2005) have written counter arguments.

First, the cognitive argument; practicals can confuse as easily as they can clarify or support understanding (Wellington, 2002). When something goes wrong students are left with mixed messages and therefore may not understand or can confuse the theory. From this students may also get the impression that science never works (Parkinson, 2004). For this reason teachers sometimes rig the experiment to obtain the correct result.

Practicals have been described as useful because when students see the theory being displayed before them they will believe it. In the classroom, students are accustomed to blindly believing what the teacher is saying regardless of the subject. Practicals therefore do not make students believe the theory more; but perhaps it makes them remember it more. As Driver (1989) states:

*“learners accept what they are presented with through books, teacher talk and guided experimental work because of its authoritative status. This can and does get in the way of students making sense of the ideas for themselves.”*

(p.103)

Moreover, theories are mostly abstract and cannot be visualised by doing a practical (Wellington, 1998). Students must first be trained in what to look for and then they may be able to visualise the theory; for example, when doing an experiment with students to observe onion cells under a light microscope, most students do not see cells, it is only after distinct features have been pointed out such as the nucleus that they start seeing cells the way intended.

Science processes are situated in science; they are not context-free and transferable. For this reason science teachers cannot teach theory through practicals (Wellington, 2002). Students cannot just be exposed to phenomena or events or observations in the hope that they will somehow induce or discover the theory. Students need to be taught that not everything in science can be related to laboratory experience and to doing things.

Learning about science, must be separated from learning to do science, as the two are not one and the same thing. Whilst there are some basic skills and investigative methods that are best learnt by doing practicals, such experiences are rarely an appropriate vehicle for developing a knowledge and understanding of science itself (Osborne, 1996).

It has also been said that practicals are interesting and exciting. However, some students do not like them and for those who find practicals interesting and exciting, little is known of what they actually like. For some students, it is likely that their enjoyment of practicals comes from the opportunity it provides to talk to fellow class members. They may also like the break it gives them from listening to teachers and from writing (Bennett, 2005).

Though manipulative skills and measurement skills may be improved through practicals there is little evidence showing that skills learnt in science are either of general or vocational value (Wellington, 1998). Furthermore, detailed research about the extent to which skills acquired in science lessons might be transferred to other situations is sparse (Bennett, 2005).

It has been claimed that practicals enhance skills of communication, interaction and co-operation. However, effective group work does not always happen as students often engage talking about something other than the task at hand (Parkinson, 2004). Also particular members of the group may dominate the activity or else some, out of sheer lack of interest, do not help the others.

Practicals are believed to develop skills of 'scientific enquiry' or scientific method. Yet, students may become confused about the different approaches to scientific enquiry if the nature of practical activity is not clearly explained (Parkinson, 2004). Fullick (2005) states that science investigations can be confusing because not only are students expected to gather data to test a hypothesis or to understand a relationship between variables but they are also expected to do it in an acceptable scientific manner.

Wellington (1998), further accuses practicals of failing to reflect 'real' science because there is usually a single, prescriptive framework for experimental and investigative work

and this does not reflect the variety of activities engaged by different scientific disciplines such as biotechnology, astrophysics and zoology.

Millar (1998) questions how practicals illustrate phenomena as students often do not test the real phenomenon but a model of it. He gives the example of the experiment to investigate how substances move into and out of the small intestine using visking tubing. The students are not seeing an actual intestine but a model of it and therefore it does not illustrate how food passes through the small intestine. Hodson (1988) also states that:

*“... children are seriously misled by teachers who pretend that they are testing a theory when, in reality, they are illustrating it. The so-called rigorous testing of hypotheses by experimental methods that is given pride of place in the Nuffield courses is something of a sham, because success is guaranteed and is under-written by the assumptions of the very theory that is supposed to be under test.”*

(p.27)

Some counter arguments have also been written for the aims given to practical work.

## **2.6.2 Counter-Arguments concerned with the Aims for doing Practical Work in Science**

### **To Enhance the Learning of Scientific Knowledge**

Practicals have been described as being able to illustrate, verify or affirm ‘theory work’. They have also been described as helping to develop understanding (Wellington, 2002). However, studies of students’ laboratory activities have reported that many students gain little insight from school laboratory activities, either about the major concepts involved or the process of knowledge construction (Novak, 1988). Even when the outcomes of the experiment are as the teacher intended, conclusions which seem ‘obvious’ to the teacher are less so to the students (Millar et al., 1999).

Some researchers (such as Hofstein and Lunetta, 2003) have found that often students are not aware of the purposes and aims of practicals. They often perceive that the principal purpose for a laboratory investigation is either following the instructions or getting the

right answer rather than to help them learn theory or to illustrate a phenomenon. Wellington (2002) believes that the aim of practical work is to confirm answers which others have already worked out rather than arriving at answers they deduced for themselves.

According to some researchers (Millar et al., 1999; Hofstein and Lunetta, 2003), students do not have enough opportunity to play with ideas because time is limited and teachers often spend large portions of laboratory time in managerial functions. To many students, a laboratory means manipulating equipment but not manipulating ideas (Hofstein and Lunetta, 2003). Gunstone (1991) claims that,

*“students need to spend more time interacting with ideas and less time interacting with apparatus.”*

(p. 74)

Furthermore, students often fail to make the connection between the practical and the theory. To this end students often order their laboratory experiences and construct regularities in ways that are not compatible with the theory that the teacher wanted to teach (Roth et.al. 1997a) and during demonstrations, students often pass comments that are irrelevant, and even contradictory, to the laws which the teacher wanted to explain (Roth et.al 1997b). Friedler and Tamir (1986) reported that secondary students in Israel seemed to experience the presence of weak links and even gaps in their knowledge which slow down students’ understanding or even mislead them.

The reason for these difficulties may be because teachers often do not perceive that laboratory activities can serve as a principal means of enabling students to construct meaningful knowledge of science, and they do not solicit and probe ideas and encourage them to consider and test alternative hypotheses and explanations (Hofstein and Lunetta, 2003).

### **To Teach Procedures and Train in Laboratory Skills**

Practicals have been justified on the basis of teaching students the skills and techniques needed to become scientists. Hodson (1990) points out that it is difficult to justify their inclusion in the science curriculum for everyone simply on the basis that they will be

needed for future scientists. While there is some truth in this, it could also be argued that the curriculum in any subject must, in part at least, include aspects required by future specialists (Bennett, 2005).

Students fail to learn from practicals the skills that were intended for them to learn. This is because practicals are often carried out rapidly using unreliable equipment or without enough attention to precision (Millar et al., 1999). Woolnough and Allsop (1985) add that the sophisticated apparatus found in most science laboratories restricts creativity and contributes to removing the science learned in schools from the students' real world.

Some practicals aim to teach students how to design their own experiment and how to solve problems. However, most problems encountered are closed problems and students often know the result of the experiment beforehand and for this reason the task becomes a lengthy elaboration of the already known (Jenkins, 1999).

In a local setting, Mifsud and Muscat (2006) found that Maltese secondary school Chemistry students have limited exposure to hands-on practical situations and that practical work was done as group work or as teacher demonstrations. So students have poor practical skills and are unable to handle apparatus. Students experienced difficulties when making inferences in practicals since they were unable to explain a good observation. This is because of the common practice of carrying out step-by-step processes and coaching students to pass examinations. As a result 16+ students starting A-level Chemistry were not prepared to design experiments as they were not exposed to this skill.

Busuttil (1996) also found that at O-level students do not acquire the skills in practical training that are fundamental for A-level Biology. He found that students were not being led to arrive at conclusions through research methods and problem solving. He concluded that perhaps the laboratory is not being used to provide students with enough opportunities to investigate, to inquire and to find out things for themselves.

Moreover there is an idea that learning science itself is best approached by doing science in a laboratory. Such an emphasis on direct experience is strongly associated with the

conception that scientific knowledge is lying around out there to be discovered by the curious. However, many of the ideas of science are neither self-evident nor easily 'discovered' (Osborne, 1998).

### **To Show Students the World of Scientists and Provide Insight into Scientific Method**

By the late 1970s, a number of concerns were being raised about the legitimacy of encouraging students to 'be a scientist' (Bennett, 2005). This is because there is a problem with the enquiry approach in that while the scientist is working on the border of human knowledge and is finding out the unknown, the student is finding out what everybody already knows (Newman, 1982 as cited by Millar, 2001) as the experiments students engage in are well documented. Millar (1998) believes that for this reason:

*“Learners clearly find the role of ‘scientist’ a difficult one to sustain in the teaching laboratory – and for good reason.”*

(p.18)

In addition, different people view the meaning of being a scientist and the way a scientist works, differently (Woolnough and Allsop, 1985). Jenkins (1999) adds that whether methods of teaching practical science actually exist or whether they are used by practising scientists themselves or are the cause of their successes has been debated since science was judged to be distinct and progressive to merit special account. Also many teachers do not think that helping students understand how scientific knowledge is developed and used in a scientific community is an especially important goal of laboratory activities for their students (Hofstein and Lunetta, 2003).

Moreover students cannot just engage with enquiry learning and discover new theories. Scientists test their ideas about natural phenomena by drawing on their body of knowledge to make conjectures about the behaviour of the phenomena in question and the underlying causal mechanisms. Osborne (1996) argues that students cannot go through the same process as the body of knowledge is not acquired yet.

Millar (1998) states that the development of a theory almost always comes from someone who is very familiar with all the data available and the step of generating an explanation is

a creative and imaginative one. There is no automatic mechanism by which an explanation must emerge if enough data is assembled. On a school level, it is implausible that most learners would ever come to an idea such as this without being told by someone else. The reason why we celebrate the genius of the great scientist is precisely because the generation of explanatory ideas such as these is not an automatic routine process of taking care in observation and measurement and following a method. It requires lengthy periods of immersion in, and struggle with, the phenomena involved and peculiar insight. Learning situations cannot provide the former, and it would be unrealistic to expect the latter of all learners (Millar, 1998). To this end,

*“very few ‘experiments’ in school science are really experiments. It is just that we have all (teachers and pupils) got into the habit of calling them that.”*

(Wellington, 2002, p.62)

In school many students engage in laboratory activities in which they follow a cookbook approach (Roth, 1993). This was also found by Attard (2006) in her study of students' perceptions on the adequacy of the Biology SEC syllabus in which she found that the most common form of practicals carried out in schools was recipe-type experiments, promoting mostly the handling of apparatus, observation and communication of results.

The student's laboratory guide, handbook or worksheet focuses students' attention on the questions to be investigated and on what is to be done, observed, interpreted and reported and gathers and records data without a clear sense of the purposes and procedures of their investigation and their interconnections (Hofstein and Lunetta, 2003; Ottander and Grelsson, 2006). When Ottander and Grelsson (2006) analysed the laboratory task sheets of two schools they noted that planning was rarely practised or assessed. In addition, the quantity of information presented in the laboratory guide is often so substantial, according to Johnstone and Wham (1982) that the details can distract the learner from the main goals of the practical task.

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## **To Motivate Students and to Develop Positive Attitudes to the Subject**

Increasing student motivation has often been listed as a reason and an aim of practical work. Jenkins (1999) however questions whether practicals are the most effective way to increase interest in young people towards science in today's electronic world.

In school laboratories, students are lacking the motivation to act as enquiring scientists. This may indicate the artificial and inhibitive nature of school science lessons and therefore of practical work, and because of it students are being seen as having a lack of scientific potential (Woolnough and Allsop, 1985). It may also indicate that the work assigned is not interesting and does not lead to inquiry and problem solving. Motivation varies with age (Stark and Gray, 1999; Pell and Jarvis, 2001). Young students may be more motivated by the experiment itself and with using apparatus whereas older students may need more stimuli.

### **2.7 The need to know Students' Perceptions**

There exists a large volume of literature about students' attitudes towards science. This indicates the importance given to affective factors in influencing students' responses to lessons (Bennett and Kennedy, 2001). Ramsden, (1998) stated that at the simplest level the purpose of much attitude research in science education has been to examine which students' experiences or perceptions of science seem to alienate the majority from science and possibly suggest some insights as to how the problem might be resolved. This is tied to a concern over the uptake of science subjects at both the secondary and tertiary level. According to Hofstein and Lunetta (2003) experiences that promote positive attitudes should be examined as they could have very beneficial effects on interest and learning in science.

One area which requires more study, according to Hofstein (2004), is that which will assess how the time spent on laboratory work and how specific activities (such as open-inquiry) in the laboratory affect the learning environment. Research intended to understand whether practicals promote positive attitudes and whether students are learning what was intended may include science laboratory activities viewed from the perspective

of students. Students make good subjects as they would not know the theory the experiments were intended to teach (Wallace and Loudon, 2002). Highet (2003) states that emerging sociological perspectives view young people as social actors in their own right. From this standpoint students have a right to have their voices heard and their opinions sought in matters affecting their lives. Treating students as 'experts' on their own lives can help to balance the power dynamics in the research relationship and create a safer, more relaxed atmosphere and encourage the generation of richer, more insightful data which more accurately represent aspects of students' lives. Explicating goals for specific students' learning outcomes should serve as the chief basis upon which teachers could design, select, and use activities; the goals can also serve as the most important basis for assessment of students and of the curriculum and teaching strategies (Hofstein and Lunetta, 2003).

Teachers' job satisfaction is likely to be strongly influenced by their students' affective responses to their lessons and also to the practical activities they planned. A lot of effort is put into revising and altering the practical activities in order to try and increase their students' engagement with science and their interest in studying science subjects. It is hardly surprising that they wonder if their efforts are successful and ask how they might find out.

Millar (1998) believes that research into students' perceptions would help eliminate a number of myths about practicals and its educational purpose. Becoming clearer about the real purposes of practicals may allow for better planning of practical activities which are more effective and use the learning time more efficiently.

The next section explores some of the research done about students' perceptions of practical work.

## **2.8 Research about Students' Perceptions of Practical Work**

Numerous researchers (such as Stark and Gray, 1999; Braund and Driver, 2005) have explored whether students' perceptions of practicals differ depending on the grade they are in. Stark and Gray (1999) and Pell and Jarvis's (2001) studies on practicals reported that

young students, particularly the 11/12-year-olds, were motivated and would attempt almost any work put in front of them and were willing to tackle unfamiliar questions. The 10/11-year-old students had a preference for independent investigation and the study of science in social contexts. On the other hand the 13/14-year-olds were less motivated and more likely to fail to complete questions which looked unfamiliar or challenging.

Similarly, Galton (2002) detected noticeable dips in students' attitudes to science in 10/11-year-olds and suggested that this decline in liking for science was connected to fewer independent investigations being carried out.

In their study Braund and Driver (2005) also reported that many 11/12-year-old students described one of the main differences between practicals carried out in secondary school and that in primary school as being that in secondary school they were actually doing practicals whereas in primary they did not do any. They also found that the younger students (10/11-year-olds) were much more likely than their 11/12-year-old counterparts to see practical science as useful in improving job prospects and they were also surer that practical science might help further study.

Nott and Wellington (1999) conducted a study on students' perceptions of practicals by working with students who had completed a science course. They found that most 14/15 and 15/16-year-old students were eager to do practicals. They believed that they had been able to follow instructions for practicals including written instructions although just under one third felt that they were not sure or did not find the guidance for practicals clear. However, approximately a quarter of the students across all grades were uninterested in investigations.

Another study conducted by the Qualifications and Curriculum Authority (2004) with 11 to 14-year-old students, found that practicals were the aspect enjoyed most by the students and likewise many found this kind of work easy. Factors which the students found difficult included writing up and recording the experiments. Students indicated that they would like to do more experiments in their science lessons and they would like to have less writing.

In a Maltese study conducted by Debono (1999) about students' attitudes to Chemistry, it was reported that students said that practicals are the aspect of Chemistry that they like most. When they were asked what they would like to change, more practical sessions ranked third. The laboratory report book was ranked sixth when they were asked to mention what they hate the most in Chemistry.

In a study on students' and parents' views of the School Science Curriculum, Osborne and Collins (2000) found that across the groups, the features of Chemistry that generated interest among students were those which were concrete, observable and manipulable. The interest of continuing science was heightened when opportunities for autonomy were presented, such as choosing from a range of tests to be carried out or in the selection of appropriate equipment.

Some researchers investigated gender and whether there were any differences in the laboratory. According to Kelly (1987), boys act as though they have automatic priority over the resources of the laboratory, whether they are the apparatus, the teacher's attention or just the physical space. She believes that during early adolescence boys dominate girls in terms of toughness. When dealing with potentially dangerous apparatus boys' toughness may give them a real advantage during experiments. To this end Murphy (1994) reports that girls' lack of confidence in practical contexts and fear of practical equipment has also been commented on in several studies. Therefore one would expect that girls do not perceive practicals in a positive light.

Murphy (1994) also found that at age 14 there was a gender difference in laboratory skills which were not present at age 10 or 17. The study found that girls specialising in Physics did less well than boys in all science areas, whereas female chemists and biologists only did less well in Physics.

In another study about gender preferences in learning science, Stark and Gray (1999) found that at 11/12 years, the main differences between boys and girls were 'Discussing science in groups' where boys enjoyed the activity more than the girls. Girls preferred 'Teacher demonstrates' and were also more favourably disposed towards writing about their science activities than were the boys at this stage.

In the case of problem-solving experiments, girls' solutions were found to be judged as failure either because their problems were not recognised or because they were not valued (Murphy, 1994). Stark and Gray (1999) also report that at 13/14 years, boys were generally more positive than girls, particularly towards problem-solving.

Some research has concluded that male behaviour robs girls of teacher time in many classrooms (Frost, Reiss and Frost, 2005). Kelly (1987) looked at student-teacher interactions in workshops and laboratories. She found that girls had more contacts with the teacher and of longer duration than boys. She continued that teachers, rather than building up girls' self-confidence, accepted their dependence on them and thus reinforced their feelings of helplessness. The combination of girls' timidity and boys' bravado lead to girls being marginalised in laboratories which she predicted to lead to a real lack of skills in girls and to a substantial problem in future motivation.

Recent studies looking at classroom intervention strategies have recommended practicals as a way of combating gender differences (Murphy, 1994). Smail (1987) recommended that experiments need to be interspersed with more explanatory discussions, reading and written work to improve girls' enjoyment of practicals.

The next section will explore research dealing with teachers' perceptions of practicals.

## **2.9 Teachers' Perceptions of Practical Work**

Given the great differences between the experiences of teachers and students, it is not surprising that when students look at the world they structure it differently. Some researchers investigated how teachers perceive practical work.

Using teacher interviews, Ottander and Grelsson (2006) reported that teachers thought that the main goals of laboratory work were to connect theory to practice, stimulate interest and enjoyment, and practise laboratory skills and techniques.

However in their study, Yildiz et al. (2006) reported that items related to enhancing scientific curiosity and helping them gain the sense of possession of laboratory work were

considered by teachers to be the least important items when compared with other items in the scale.

In local schools, teachers stated that the aim of practical work is to involve students in problem solving activities and to satisfy the requirements of SEC. Most teachers also stated that practicals are useful for students to acquire abstract ideas and that it leads to better understanding (Xuereb, 1996).

Swain et al.'s (2000) study of teachers' concerns, found that teachers are mainly concerned with the nature of science as an activity involving observation. They are also concerned with the pedagogic requirements of teaching science and with the skills required for doing practicals. These concerns have remained unchanged between 1979 and 1997 however, teachers in 1997 gave more priority to problem-solving and affective factors.

Chin-Chung (2003) reported that teachers clearly showed how their views on the purposes of laboratory activities guided their perceptions and actual practice of school laboratory activities. Such views may be related to epistemological beliefs about science. Parkinson (2004) wrote that teachers' views about practicals are influenced by a number of factors such as:

- their own experience of science at school;
- learning about practicals and classroom practice during their education and training course;
- the scheme of work and the textbooks used;
- colleagues in the science department;
- Government initiatives, e.g. the National Curriculum, GCSE specifications.

Souza Barros and Elia (1997) believe that certain attitudes held by the teachers can affect the learning process negatively such as the fact that most teachers do not carry out innovations of new curricula and methodologies. This is partly due to entrenched beliefs about teaching science as telling science, instead of teaching that science as a way of thinking. There seems to be a difference between what teachers believe and say, and what teachers do in class. In a study of the beliefs and opinions of science teachers, Souza Barros et al., (1987, as cited in Souza Barros and Elia, 1997) indicated that though Physics

teachers were less dogmatic than other science teachers (Biology, Chemistry, Mathematics) about the nature of science and approved curricular modifications and active methods in the classroom, the way that they teach in the classroom indicated otherwise. Gardiner and Farragher (1997) and DeCarlo and Rubba (1994) reported similar findings for Biology and Chemistry respectively.

In their study Pekmez, Johnson and Gott (2005) investigated teachers' views on practical work. They found that while some teachers distinguished 'investigations' as a type of practical concerned with problem-solving, other teachers seemed to believe that the only aim of practical work was to support the substantive explanations of science, and laboratory work was merely a teaching method towards this end.

Xuereb (1996) also found that though teachers believed that laboratory activities are not distinct (53.4%) from theory and should support one another (92.2%), few teachers used experiments through which theory is learned because it is very time consuming.

Chin-Chung (2003) reported that students' and teachers' perceptions of the laboratory and their preferences to laboratory work differ. While students would prefer a laboratory learning environment where they could have more student cooperation, conduct more open-ended inquiry, explore more deeply into the connections between theory and practical evidence, while having clearer rules for guidance and better material support than they actually experienced, their teachers did not show any gap between their perceptions of actual laboratory learning environments and those they would prefer, except on the single aspect of material support. The teachers emphasised that the actual material environment in school laboratory should be greatly improved.

Chin-Chung (2003) also showed that junior high school students were less satisfied with the approaches to actual laboratory activities than their teachers. The students preferred more student-cohesive, open-ended, integrated and rule-clear laboratory environments than their teachers. The teachers showed stronger preferences for better equipment and material environments for laboratory work than their students.

Chin-Chung, (2003) believes that teachers and students have different perceptions about laboratory learning environments. Some science teachers hope that students can engage in a wider range of learning experiences than simply verifying textbook claims, but students often merely work toward the 'aims' of laboratory activities. Alternatively, students may prefer to develop a better understanding of the concepts and nature of science and scientific inquiry through laboratory work, but science teachers may not actually provide such laboratory environments or recognise these purposes.

Nott and Wellington (1999) claim that investigative work was introduced without adequate guidance or in-service training, for these reasons, teachers perceive it as flawed and resent its imposition. For secondary teachers, scientific investigations have become a chore and a task to be endured rather than an opportunity to teach and learn science and about being a scientist.

## **2.10 Assessment of Practical Work**

Most of the assessment of students' performance in the science laboratory continues to be confined to conventional, usually objective, and paper and pencil measures. Some science teachers regard curriculum requirements for practicals as a straitjacket, with the main focus being helping students gain good grades in examinations (Braund and Driver, 2005).

Bol and Strage (1996) believe that often teachers desire to develop students' higher order thinking skills such as critical thinking; however, this is not reflected in their assessment practices. This may be due to many teachers lacking experience with assessment methods aimed at assessing their students' understanding and performance in the science laboratory (Yung, 2001). As a result, in many cases, students' final grades do not include a component that directly reflects their performance in practicals and their understanding of that work. Furthermore, Brickhouse and Bodner (1992) reported that students' concerns about their grades have a strong influence on teachers' practices. It is well known that the assessment model used influences how and what students learn (Boud, 1995).

In Malta 15% of the SEC examination marks of Biology, Chemistry and Physics are taken from the experiment reports done. For this school-based assessment teachers award marks

out of 15 to the reports done. Xuereb (1996), reports that teachers complain about lack of guidelines on how to assess work.

Millar (1998) says that end of course practical examinations are time efficient and more objective to teacher-based assessment. However they run the risk of not providing adequate opportunities to demonstrate the range of skills acquired during the course and they may cause teachers to become more focused on skills and techniques more likely to come out in examinations. On the other hand, course-based teacher assessments permit a wider range of practical abilities that can be tested and give students more opportunities to demonstrate their abilities and places high demands on the time and skills of teachers.

Busuttil (1996) however, believes that the coursework mark is in no way indicative of practical skills possessed by the student. In his study of the practical skills of Form 5 Biology students he did not find a correlation between the practical test marks and the coursework practical marks which shows that teachers are not properly assessing the actual practical skills of their students.

## **2.11 Conclusion**

Further research into students' perceptions of practicals has something to offer by way of possible explanations for the persisting problem of the apparent alienation of young people from science. If carefully focused and designed, this research could go one step further and provide a sound basis on which to make informed decisions about aspects of classroom practice. These, in turn, might enhance the experiences of young people in their science lessons. In this way we may interest more young people into choosing to study science subjects because they feel science really does offer them something of use and interest (Ramsden, 1998) and also to make sure that all the effort, school funds and time dedicated for practicals serve the intended functions.

## **Chapter 3**

### Planning and Designing the Study

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### 3.1 Introduction

My intention was to study an area which I felt was important to my teaching career, to the school I in which work in and also to the students whom I teach. Watt (2007) stated that topics should be chosen on the basis of what a researcher believes is most worthwhile. The study investigated students' perceptions regarding practicals and whether these perceptions change with age, gender, and the subjects chosen. It was intended that the results of this study would provide guidance in redesigning certain aspects of laboratory work and help anticipate the reaction of students and teachers to particular recommended enhancements. The results allowed me to reflect on my teaching methodology and suggest improvements to my colleagues.

### 3.2 Choice of Location

The data were gathered from an independent co-educational school in Malta. The senior school had a population of 379 students, with five grades each having approximately eighty students. The school was chosen because I was working in the school; this cut down the time required for familiarisation with the dynamics within the school and transport time. Being a teacher in the school also allowed enough flexibility to give the questionnaire to all of the students. This was important as it was felt that if general conclusions were to be drawn, the sample had to truly reflect the major characteristics of the population it represented (Entwistle and Nisbet, 1972).

The results of the study were of personal interest as I had taught most of the respondents and therefore I was involved in the planning and conducting of practicals at the school. The added bonus of having taught most students was that they felt at ease when asking me questions regarding the purpose of the questionnaire and they were willing to volunteer information to help in my studies.

The school proved to be ideal as students were exposed to science from Grade 8 (11/12-year-olds) and most lessons were carried out in the laboratories. Experiments were carried out regularly in all grades and students wrote reports after experiments. This added the dimension of assessing change in perception as they progressed to higher grades. Examinations in all grades included questions regarding the experiments and from Grade

10 (13/14-year-olds) an average mark for the reports was included in the annual examination mark.

The study reflected the perceptions of students with different abilities and of both sexes as the school also prides itself of having classes with students of mixed ability and of being co-educational where all lessons involve both girls and boys.

### **3.2.1 Receiving Authorisation**

The necessary authorisation was obtained from the School Principal and an agreement was reached to administer the questionnaires during free lessons. This was important as I did not want my research to take time from lessons.

### **3.2.2 Choice of Respondents**

The students involved in the study were 11 to 16 years of age and had been attending the school from the beginning of the scholastic year 2006-2007. In addition, they must either have been studying General Science or else one or more from Biology, Chemistry and Physics. Students study General Science in Grades 8 and 9, then in Grade 9 they choose which science subject (Biology, Chemistry, or Physics) or subjects they are going to study for SEC level.

Students were chosen as respondents for this study because, as mentioned in the previous chapter, treating students as 'experts' on their own lives can help to balance the power dynamics in the research relationship, and create a safer, more relaxed atmosphere and encourage the generation of richer, more insightful data which more accurately represent aspects of student's lives (Hight, 2003).

## **3.3 Choosing the Research Method**

A case study was chosen as a research strategy because they have proven to be ideal when a holistic, in-depth investigation is needed (Yin, 2003; Cohen et al., 2004). This is because they are designed to bring out the details from the viewpoint of the participants by using multiple sources of data (Hitchcock and Hughes, 1995; Tellis, 1997). Case studies

emphasize detailed contextual analysis of a limited number of events or conditions and their relationships (Palmquist, 1997). The intention of the study was not to generalise findings to all schools, but other teachers may recognise similarities in contexts and be able to apply certain findings to their situation.

### **3.3.1 Qualitative and Quantitative Research**

Hara (1995) stated that the decision as to which research approach should be chosen depends on the research subject, research aim, the situation and the researcher's belief.

Both quantitative and qualitative data were obtained during this study. The quantitative research approach was used to obtain entire trends which were compared in the research. Yet the limitations in a numerical presentation of the complexity of human behavior were recognised (Solutes, 1990) and to this end qualitative research was also conducted to gain a total or complete picture. According to Stainback and Stainback (1988) qualitative research provides a holistic description of events, procedures, and philosophies occurring in natural settings and these are often needed to make accurate situational decisions. This differs from quantitative research in which selected, pre-defined variables are studied.

### **3.4 Planning the study**

Padak and Padak (2007) identified four stages when planning research:

1. Identifying questions to guide the research. This entailed identifying and precisely defining the problem by asking 'What is the purpose of the investigation? What am I trying to achieve with such an investigation?' Reports about previous research on relevant topics were read in order to gather information about similar research done in the area.
2. Collecting information to answer the questions. This involved selecting and defining the sample to be studied, deciding on techniques to be used for collecting information and data collection.

3. Analyzing the information that has been collected. Data analysis involved examination and interpretation of the data in order to answer the research questions. This involved deciding on the tools for processing, analysing and interpreting the results.

4. Sharing results with others. The thesis was written to try and answer the research questions (Entwistle and Nisbet, 1972) and addresses concerns of many teachers. Sharing the results was an important outcome of this work.

### **3.5 Identifying the Questions to Guide the Research**

The central research questions involved the elucidation of opinions of secondary school students aged 11 to 16 regarding the laboratory experience in general, the perceptions of the purpose and nature of practicals and report writing, desired changes in the laboratory, and insight into how they perceive the current assessment method.

Questions that guided this study were:

1. Do students' perceptions of practical work differ as they progress academically?
2. Are students satisfied with the amount of practical work done?
3. What do students think are the factors that make a 'good experiment'?
4. How are students given instructions and how can these be improved?
5. What do students think the purpose of report writing is, and do they think that the marking scheme is fair?
6. Which are the things that make experiments enjoyable or not for students?
7. Do students feel like a real scientist when doing experiments?
8. How do students think experiments can be improved?

### **3.6 Collecting Information to Answer the Questions**

It was decided that data from students would be collected by means of a questionnaire. Its construction involved interviews with Grade 12 students and piloting the questionnaire. This was then followed with teacher interviews to achieve triangulation.

### 3.6.1 Planning and Interviewing Grade 12 Students

A set of eight Grade 12 students were interviewed at the end of the 2005-2006 scholastic year so that their experiences would be relatively fresh. Grade 12 students were chosen because they had been the longest in the school and therefore could provide more insight than younger students. Also I thought that Grade 12 students may feel that they can be more truthful as their time in the school had ended.

The interview was preferred as the research tool at this stage as interviews are personal and they are generally easier for the respondent to answer, especially if what is sought are opinions or impressions as in this case (Trochim, 2006). The interview was semi-structured and this type of interview was preferred as:

- the audience was specifically targeted;
- questions were structured to allow comparisons;
- the questions gave the freedom to explore general views or opinions in more detail (Powney and Watts, 1987).

An interview schedule was prepared which included 28 questions based upon issues encountered in the literature rather than solely on my personal views (refer to Appendix 1). Questions were formulated to provide an atmosphere of open and undistorted communication between the interviewer and respondent (Holstein and Gubrium, 2003). They targeted frequency of practicals, the reasons why practicals were done and their link with learning, their understanding of practicals, the help given during experiments, the level of difficulty, report writing, assessment, enjoyment of practicals, whether practicals made them feel like a scientist and suggestions for improvement. When planning the interview, care was taken as:

- interviewing skills were required;
- skills to analyse the data were needed;
- they were time consuming and resource intensive;
- it was made sure that the questions were not prescriptive or leading (Cohen, et al., 2004).

The interviews were done to check that the organisation of the questionnaire met the requirements of the research project, to provide some indication of the range of responses

to be expected and to be able to validate possible survey questions (Powney and Watts, 1987).

Students volunteered to come for the interview after their SEC exams. Four students were chosen; I tried to choose students who had more than one science subject as I thought it would offer more insight into the differences between subjects. The students were also of mixed gender and they were all asked to bring someone whom they felt comfortable with from the same grade. Students were interviewed in pairs; this was done so that they felt at ease when answering the questions and possibly this would shed further light on findings (Highet 2003).

The paired interviews were relatively easy to set up, participants were comfortable and familiar with one another and thus a naturalistic context was achieved. This gave them some degree of control over the interview and facilitated a better balance in the relationship between interviewer and participants. Interviews were conducted in private, the Biology laboratory was used as I knew it would not be frequented and a note was placed on the door telling passers-by that an interview was in progress. The privacy and willingness of the students helped assure the attainment of richer data rather than obtaining mere opinions (Holstein and Gubrium, 2003).

Students were briefed with information regarding the purpose of the study and credence was given to the endeavour (Eales, 1987). Powney and Watts, (1987) believe that students are likely to be more forthcoming when told that their information would be used to provide an improvement in education in general. They were reassured that anonymity would be preserved throughout the inquiry and in any subsequent publications.

The questions were read as they were worded in the interview schedule and they were only repeated when requested by the respondent. When clarification was asked, it was given in a nondirective manner. I paid attention not to answer for the respondent and nondirective information was not given. Personal experiences and opinions were not put forward and cues that would have led the interviewee to respond in a particular way were eliminated (Powney and Watts, 1987).

The relative positions of the interviewees and the interviewer were of people having a normal conversation, that is, directly opposite and in a position in which eye contact was

made and where non-verbal signals could be picked up. Interviewees were not allowed to sit close enough to read the interviewer's questions and notes (Powney and Watts 1987).

Each interview took approximately twenty-five minutes. They were recorded using a tape recorder. A spare tape was kept (Powney and Watts, 1987). A pre-test was done to check the clarity of the voices and the level of sound. After the session, interviews were transcribed and they provided a relatively complete and highly accurate representation of how the conversation developed in the course of the interview. Since interviews were all conducted by me, the question of variation between interviewers did not arise (Entwistle and Nisbet, 1972).

### **3.6.2 Constructing the Questionnaire**

The interview assisted in developing relevant lines of questions possible and provided some conceptual clarification for the research design (Yin, 2003). The responses to the interview were used to check the clarity of the question and to see where I could probe deeper. They were used to see whether there might be an interesting aspect I may have missed and whether there might be a trend unique to this school worth exploring. It also showed that having a questionnaire with closed questions only would limit the responses.

Two questionnaires were designed to investigate students' attitudes and perceptions vis-à-vis practicals. One questionnaire was intended for students taking General Science and another for students taking one or more of the separate sciences (Biology, Chemistry and Physics). These were compiled considering the transcripts of the interviews with Grade 12 students together with the relevant literature.

Questionnaires were used as social conventions operate strongly in a face-to-face situation and may prevent the person from expressing what he feels to be socially or professionally unacceptable views (Entwistle and Nisbet, 1972). The main reason for using a questionnaire was the efficiency involved as responses were required from approximately 390 students.

The questionnaire was designed bearing in mind two objectives:

- to maximise the proportion of respondents answering all of the questions in the questionnaire;

- to obtain accurate relevant information for the research

and therefore thought was given to the questions asked, how they are asked, the order of the questions, and the general layout of the questionnaire (Leung, 2003). Both first and second order questions were included in the questionnaire. First-order questions are of a matter-of-fact type and are commonly concerned with issues such as the performance of students. Second-order research questions focus upon the experience of learning as it appears to participants in which, it is the learners' own experience of the learning that is important (Marton, 1981).

The questionnaire was composed of thirty-two questions (refer to Appendix 2). It was easy to fill in and took students approximately 25 to 30 minutes to complete. The questions were grouped depending on the topic such as those about the frequency and the purpose of practicals, how the practicals are carried out, report writing and their preferences.

A variety of question formats were included to maintain the respondents' interest (Leung, 2003) and to suit the type of information requested. The questions used were of two types, closed and open ended. Twenty-one questions were closed as these offer many advantages in terms of time. Students were expected to tick the appropriate answer since putting it was familiar to most respondents. Closed questions were used as they prompted the respondent to rely less on memory in answering a question and did not discriminate unduly on the basis of how articulate the respondents were. For questions which had a Likert-type scale, an odd number of options was given. O'Brien (1997) believes that this allows a neutral or no opinion response. In so doing it was ensured that a sufficient choice was included to fully cover the range of answers but not so many that the distinction between them becomes blurred.

The downside of closed questions is as Oppenheim (1992) describes that closed questions do not enable respondents to add any remarks or explanations to the categories, and furthermore the categories might not be exhaustive. This was overcome by adding an open-response option "other" when students had to tick an option. In such cases students who selected "other" were expected to write down what this represents.

Eleven open-ended questions were also included to enable respondents to write free responses in their own terms and to explain and qualify their responses. Open-ended

questions were aimed to catch the authenticity, richness, depth of response, honesty and candour which, are described by some as the hallmarks of qualitative data (Cohen, et al., 2004).

The questionnaire was organised and worded to encourage respondents to provide accurate, unbiased and complete information. Questions were phrased and unnecessary adjectives were avoided. It was also made sure that questions about frequency were not open to interpretation (O'Brien, 1997).

The questionnaire for students from Grades 10 to 12 differed from that for Grade 8 and 9 students in order to accommodate the responses for different science subjects. This is because students may have different opinions about the different sciences and therefore a scale containing items relating to some aspects of 'science' may yield different responses to similar items had Biology, Chemistry or Physics been substituted for Science (Ramsden, 1998). Each question was accompanied by a table for the students to fill in. It was decided that if the question was a closed question the options would be repeated in each column (Figure 3.1) and if the question was open-ended, enough space would be provided for the students to answer within each column (Figure 3.2). Students had only to fill in the columns of the subject/s being studied by them.

8. Which order would allow you to learn better? Theory-Practical or Practical-Theory? (*Tick  the appropriate box*)

Biology	Chemistry	Physics
Theory-Practical <input type="checkbox"/>	Theory-Practical <input type="checkbox"/>	Theory-Practical <input type="checkbox"/>
Practical-Theory <input type="checkbox"/>	Practical-Theory <input type="checkbox"/>	Practical-Theory <input type="checkbox"/>

Figure 3.1: Closed question

9. Which experiment do you remember the most? (*Write your opinion in the space provided*)

Biology	Chemistry	Physics

Figure 3.2: Open-ended question

A comprehensive questionnaire, which covered all the relevant issues, was a prerequisite as in order to maintain anonymity, respondents were not asked to write their names and so I could not follow any anomalies, nor could I study trends in academic ability. Yet, the

impersonal and possibly anonymous nature of the replies to a questionnaire increased the likelihood of straight, even blunt answers (Entwistle and Nisbet, 1972).

### 3.6.3 Piloting

The questionnaire was piloted during free lessons with five Grade 9 students, four Grade 10 students and one Grade 11 student. It was ensured that some students were boys and some were girls. In the case of the higher grades it was also ensured that the choice of subject was varied to have a more reliable sample. Students were told about the purpose of the questionnaire and instructions were stated such as to work on their own ensuring anonymity as intended for the actual questionnaire.

The piloting of the questionnaire was done to determine:

- whether the questions as they were worded would achieve the desired results. The goal was to eliminate the chance that any question would have a different meaning for different students.
- whether the questions had been placed in the best order;
- whether questions were clear, succinct, and unambiguous;
- a clear-cut need for every question, peripheral questions and questions to find out "something that might just be nice to know" were avoided (Frery, 1996);
- whether additional or specifying questions were needed;
- the ease of completion and item non-response;
- logistics such as the time taken to complete the questionnaire;
- that it enabled sound analysis and interpretation;
- whether all the research questions were answered.

On completion of the questionnaire students were then verbally asked: Were the instructions clear? Were any questions unclear or ambiguous? Do you object to answering any questions? Was the layout clear and attractive? Do you have any other comments?

### 3.6.4 Finalising the Questionnaire

The validity of the questionnaire was based on its design; the questions were based on an extensive literature review as well as, the responses of the Grade 12 students and it was piloted to ensure that it was obtaining generating useful data. Although the questionnaire was relatively cheap to administer it was expensive in terms of design time and interpretation (O'Brien, 1997) and so careful planning was a must.

The analysis of the pilot questionnaire checked that the right areas were covered. It helped eliminate obvious errors in any coding system that might have been used, and identified irrelevant data that was collected (Powney and Watts, 1987) and helped identify areas not dealt with in enough detail. Using this and the student comments during and after the questionnaire, a number of amendments were made (Appendix 3):

- Separate versions of the questionnaire were designed for the Grade 8 and Grade 9 students. These questionnaires differ only in question 41, which asked which topics they preferred, as can be seen in Figures 3.3 and 3.4. These topics were taken from those topics that should have been covered by the time the questionnaire was administered.

41. Which experiments did you prefer? (Tick  the appropriate box)

- Those of Cells
- Those of Separating techniques
- Those of Electricity
- No preference

**Figure 3.3: Question 41 of the Grade 8 questionnaire**

41. Which Science subject experiments do you prefer? (Tick  the appropriate box)

- Those of Microbes and Disease
- Those of Atoms and Elements
- Those of Light
- No preference

**Figure 3.4: Question 41 of the Grade 9 questionnaire**

- In the Grade 8 and Grade 9 questionnaire, it was found necessary to change the title from 'Questionnaire about Practical Work' to 'Questionnaire about Experimental Work' as in the lower forms the terminology used is 'experiments' rather than 'practical work'. Similarly the word 'practical' was replaced with 'experiment' throughout the questionnaire, in this way technical terms that assume a certain background were avoided (O'Brien, 1997). An example is given below;

6. Why do you think experiments are done?

**Figure 3.5: Question 6 of the Grade 8 questionnaire**

6. Why do you think practicals are done?

**Figure 3.6: Question 6 of the Grade 10-12 questionnaire**

- In the Grade 8 and Grade 9 questionnaire, Question 2 asking for the grade was pre-ticked, this helped in sorting information.
- For question 38 regarding enjoyment, smileys were added. These were added to appeal and to improve accessibility of the questionnaire to the respondents (Cohen, et al., 2004).
- The questionnaire was formatted so that there were fewer spaces between one question and the next. However it was ensured that the layout was clear and that it was easy on the eye as a compressed layout would be uninviting as it clutters everything together (Cohen, et al., 2004).
- The boxes for ticking were placed before the statement and the solid line was replaced with a dotted one, this gave the questionnaire a more professional appearance.
- Clear instructions that guided the respondents were repeated before each question (Cohen, et al., 2004).
- More open-ended questions were added following close-ended questions. This was done so respondents could clarify responses (Borgatti, 1996) and also because as anonymity was desired I could not go back and ask the person again.
- More open response-options ('other') were added to some closed questions (Figure 3.7) because it has been suggested that while closed response-option questions offer the advantage that they avoided the potential problems of poor memory as the respondent was given prompts, but at the same time students should be able to write something else if the option they required was not available. For example,

18. Which type of experimental work would you prefer? (*Tick  the appropriate box*)

Designing your own experiment

Follow a given set of instructions

Teacher demonstrations

Other .....

**Figure 3.7: Question 18 with the 'other' option**

- The questionnaire ended with an open format question asking the respondents for their ideas for changes or improvements (O'Brien, 1997).

Through piloting it was calculated that the Grade 8 and 9 students and also those students taking one science subject would take approximately 20-25 minutes to complete the questionnaire. Those who study two science subjects would require 30-35 minutes and those who study three science subjects spend approximately 40 minutes. Thus the length of the questionnaire was thought to be appropriate as all students would finish the questionnaire within a single lesson.

### **3.6.5 Administering the Questionnaire**

Before the students started completing the questionnaire they were verbally told about the purpose behind the questionnaire, the importance of the respondents' participation, my responsibility for the survey, and a statement guaranteeing confidentiality.

Students were asked to work individually. They were asked to reply honestly and told that if their response is negative this is just as useful as a more positive opinion; this was done to avoid prestige bias (O'Brien, 1997; Leung, 2003).

Students who were absent when the questionnaire was administered were noted and they were given the questionnaire during their next free lesson. In this way a hundred percent response rate was obtained.

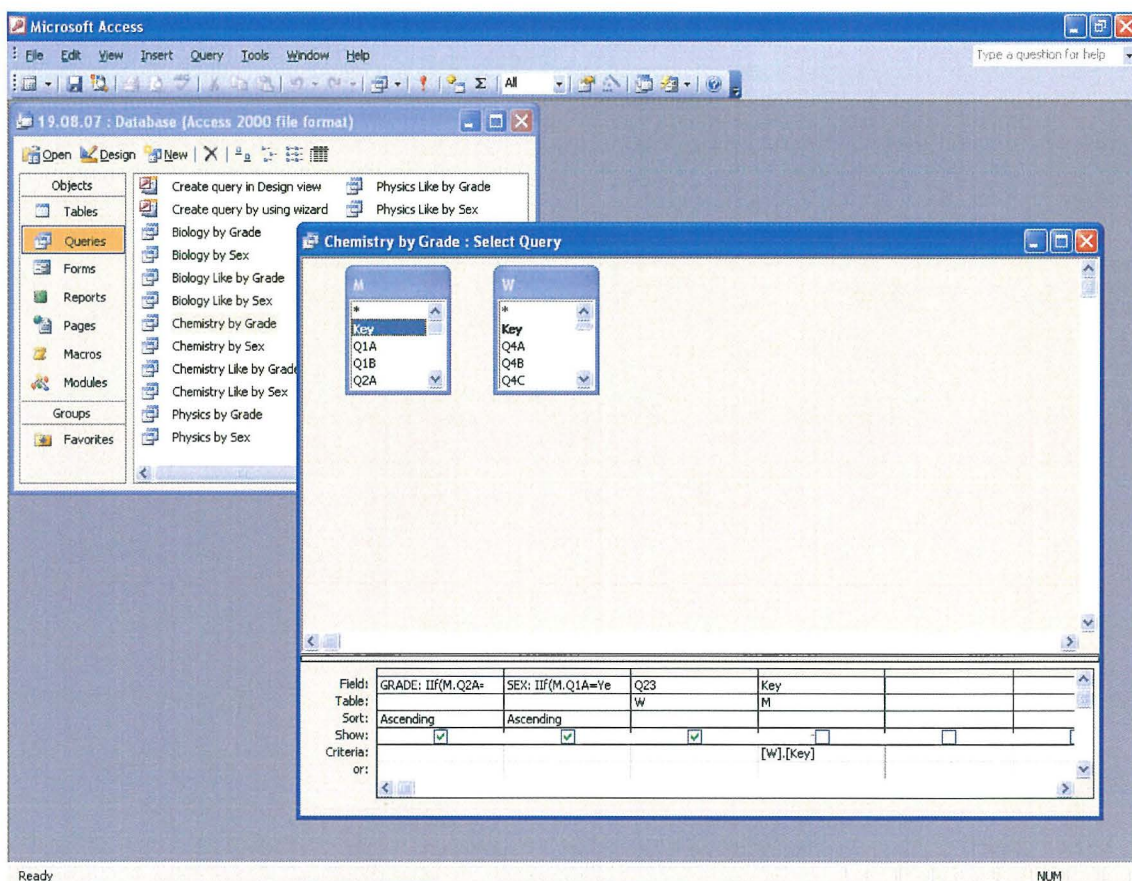
## **3.7 Preparing and Analysing Data**

### **3.7.1 Inputting and Preparation of Data**

A Microsoft Access Database was created to store the responses in electronic format. This was created so that the data collected from the questionnaires could be easily viewed, compared and quantified at a glance. The objectives of the database were identified:

- The database had to be easy to use and designed in such a way as to minimize the time required for data entry due to the volume of data available.
- Each individual questionnaire was numbered so that its electronic equivalent could be easily found.
- The database had to be designed so as to allow any possible combination of query to be run, be it based on gender, grade, subject, particular question or combination of

answers in case of multiple choice questions. For example, one may obtain information about how many Grade 10 and 11 male Biology students selected answered B, D and E for multiple choice question number 30. Figure 3.8 shows the list of queries and the ‘Chemistry by Grade’ query.



**Figure 3.8:** List of queries and Chemistry by Grade query

To this end the following steps were taken:

- The actual database was composed of six tables, one each for Grades 8 and 9 and four for Grades 10 to 12, a master table and three related tables for Biology, Chemistry and Physics.
- For multiple choice questions, an individual column for each separate answer was created rather than one column per question. This was done so that queries could be run for any permutation of answers desired seeing that certain questions did not limit the students to just ticking one answer.
- Three forms were created to allow the inputting of data, one each for Grades 8 and 9 and one for Grades 10 to 12. These were designed in such a way as to try to minimize the amount of key presses and mouse clicks required to browse through the forms.

- During data entry a unique number was automatically assigned to each respondent and written on each questionnaire so that they could be easily compared in case of doubt.

Below are some of the responses of a Grade 10 girl who studied Biology and Physics. Note that her primary key is number one; this would also be written on the questionnaire for easy referral.

Microsoft Access - [Grades 10 - 12 : Form]

Key:

Q1:  Boy  Girl

Q2:  Grade 10  Grade 11  Grade 12

Q3:  Biology  Chemistry  Physics

Q41:  Q41A  Q41B  Q41C  Q41D  Q41E

Q42:

Q49:

Biology Chemistry Physics

4 - 10 11 - 20 21 - 30 31 - 40 43 - 48

Key:

Q4:  Q4A  Q4B  Q4C

Q5:  Q5A  Q5B  Q5C

Q6:

Q7:  Q7A  Q7B  Q7C

Q8:  Q8A  Q8B

Q9:

Q10:

Record: 14 of 221

Form View

Figure 3.9: The Database

### 3.7.2 Data Analysis

Analysis involved the detailed examination of the data derived from the questionnaires. Once data entry was completed the required quantitative data to answer the research questions were extracted using queries. These data were transferred to Excel (as seen in Figure 3.10) and grouped in tables where they were sorted out according to grade, subject and gender so general trends could be recognised. Charts were created to facilitate comparisons.

The screenshot shows a Microsoft Excel spreadsheet titled "Stats.xls". The data is organized into a grid with columns representing different subjects and combinations of subjects, and rows representing different grade levels. The columns are grouped into sections: "Biology Only", "Chemistry Only", "Physics Only", "Biology-Chemistry", "Biology-Physics", "Chemistry-Physics", "All Three", "Two of Biology", "Total Chemistry", and "Total Physics". Each section has sub-columns for "Total", "Male", and "Female". The rows are labeled with grade levels from 8 to 12, with some rows further subdivided into "Male" and "Female" counts. The spreadsheet contains numerical data for each cell, representing the count of students in each category.

Figure 3.10: Spreadsheet showing data

For each of the open-ended questions a list of categories were produced. A ‘seven-plus-or-minus-two’ rule of thumb was used to indicate the number of categories that arose from the data. This was based on the notion that if there are much more than ten categories, then the analysis was becoming cumbersome; if there were fewer than four then it raises questions about the closeness of the data (Powney and Watts, 1987). Using the database, the answers to each question were listed in a manner that was easy to count the number of responses for each category (Figure 3.11). The percentages were then worked out and general trends were recognised. Quotations were used as they are a useful way to bring the text alive, of allowing the participants to make cogent points, and to make the ‘story’ more believable (Powney and Watts, 1987).

### 3.8 Teacher Interviews

The research was followed-up by an interview with the students’ respective teachers. Five teachers were interviewed: one General Science teacher, one Biology teacher, one Chemistry teacher and two Physics teachers. Their teaching experience varied. The only

GRADE	SEX	Q43
11	BOY	conclusion
11	BOY	conclusion
11	BOY	the report!
11	BOY	they are nice and short
11	BOY	sometimes they are boring and not everyone takes part
11	BOY	we don't always participate in the experiments
11	BOY	a lot of time
11	BOY	we get a lot
11	BOY	if you do it wrong you have to do it again
11	BOY	rules
11	BOY	the report after
11	BOY	the report
11	BOY	the report
11	BOY	easy
11	BOY	having to write the report afterwards even though its for my own good!
11	BOY	doing the report
11	GIRL	the groups
11	GIRL	the fact that they're too many
11	GIRL	long methods
11	GIRL	the reports
11	GIRL	there is nothing that I don't like
11	GIRL	there isn't anything I don't like
11	GIRL	nothing much. The lab reports we have to do after
11	GIRL	they are very long
11	GIRL	sometimes the reports are hard
11	GIRL	groups
11	GIRL	you have to repeat when results are wrong
11	GIRL	writing a report about it
11	GIRL	writing the report
11	GIRL	time it takes
11	GIRL	the reports
11	GIRL	they can be boring
11	GIRL	when we have to work alone
11	GIRL	nothing
11	GIRL	nothing

**Figure 3.11: Qualitative data for question 43**

teacher who teaches the respondents that was not interviewed was myself. The questions that guided this endeavour are listed below:

1. What goals do secondary school instructors have for the laboratory experience?
2. What changes would the teachers suggest with respect to the laboratory work?
3. Do teachers' perceptions about practical work match those of students?

One of the aims of the teachers' interviews was for triangulation. The interview was structured so that there was an overlap between the questions asked to the students in the questionnaire and the questions asked to the teachers in the interview. This was done to see whether teachers' perceptions about practicals match those of students. The purpose of corroboration was to help increase understanding of the probability that the findings would be seen as credible or worthy of consideration by others (Stainback and Stainback, 1988). The interview intended to investigate whether teachers were aware of the perceptions held by students regarding the practicals of their subject. Furthermore it attempted to gain an insight into the thinking behind what teachers actually do, to probe at the reasons behind

preparing practicals in such a way, what sort of help they offered students, and how and why practicals were assessed.

Therefore, the interview was designed to allow this to emerge. The main body of the interview was in three progressive stages. It began with some open questions about the aims of practicals and then moved to the purposes for doing practicals, the reports and the assessment. The last stage probed teachers' thinking through an 'interview about instances' approach, using particular experiments in each teacher's subject area as the focus of the questions. For this, examples of practical activities normally carried out by teachers of the subject were given to fit each type of practical (refer to Appendix 4). This was done so teachers knew exactly what I was referring to when asking them a question (Leung, 2003). Finally, by way of a summary, teachers were asked about how often students have practicals, their opinion about extracurricular aims of practicals and they were also given an opportunity to talk more generally about any problems associated with practicals and suggest improvements.

Prompts were prepared as seen in Figure 3.12; the prompts suggested possible answers to the respondent (Powney and Watts 1987) so that if the teacher found difficulty in finding a suitable example or suggestion they would be assisted. Further questions were also prepared so that if the teacher did not talk about the topic as intended further questions were available to encourage the teacher to delve deeper into the area. Being well prepared meant that I could focus on the interviewee and I was not anxious about what was coming next (Powney and Watts, 1987).

<p><b>Does the laboratory work have any social goals?</b></p>	<ul style="list-style-type: none"> <li>• Friendship</li> <li>• Working in groups</li> <li>• Sharing</li> <li>• Communication</li> </ul> <ol style="list-style-type: none"> <li>1. How do you value these goals?</li> <li>2. Are practicals carried out individually, in pairs or in groups? Why?</li> </ol>
---	---

Figure 3.12: Example of the main question and prompts during the interview

Before the interview, I ensured that my colleagues were informed about the nature of the research as well as the interview and the reasons for it. The interviews were conducted at school in private, at a time when both the researcher and the teacher did not have a lesson. This helped ensure that deep disclosure occurred rather than obtaining mere opinions (Holstein and Gubrium, 2003) and it did not interfere with lesson time.

Teachers were assured that what they said in the interview was confidential and that the questions did not have a right or wrong answer as the questions were about perceptions. This was done to reduce the possibility that the interviewee was susceptible to pressures that arose from the position he or she holds (Eales, 1987) and so to avoid the possibility of a discrepancy between what they said and what they actually did and think (Powney and Watts, 1987). Respondents were thanked at the end of the interview.

The interviews were tape-recorded and transcribed for more detailed examination. Verification of data followed for which transcripts were used to demonstrate the authenticity of the findings (Eales, 1987). The interviews were sorted out and analysed by comparing the answers of each question in the transcripts and identifying similarities and differences in responses. Analysing is a creative, constructive affair and is not simply an act of isolating and describing something that might be considered self-evident. Moreover, analysis is the reduction of data to some manageable amount (Powney and Watts, 1987). The responses given by teachers were compared to the responses of students.

### **3.9 Sharing the Findings**

The findings were shared informally, through conversations or discussions and also formally through the writing of this thesis. First, as the thesis was written, additional insights occurred, so in a way, the act of writing led to further analysis or interpretation. Learning to reflect on behaviour and thoughts, as well as on the phenomenon under study, creates a means for continuously becoming a better researcher (Watt, 2007). And second, writing leaves a permanent record of the research that can be used by others. This final stage in the research process was important because others can benefit and learn from the research. A science departmental meeting about practicals was planned in which the findings were shared with the teachers who took part in the interview. It was used to assess the success of practicals in our school and what may be done to strengthen that progress. A copy of this thesis shall also be given to the school Principal so that it may be used to assess

the progress of the school in this regard. Insight from the research allowed me to contribute and offer suggestions for the new science syllabus for the junior sector which intended to include experiments in the lower grades.

### **3.10 Conclusion**

Chapter 3 presented how the study was planned and designed. In Chapter 4, the data obtained in this study is presented, analysed and discussed.

## **Chapter 4**

### Presenting and Analysing the Information Gathered

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## 4.1 Introduction

The research was concerned with investigating the perceptions of students aged 11 to 16 with regards to practicals. The study aimed to see whether the students' perceptions on practicals differed depending on grade, subject and gender. Both quantitative and qualitative data were collected during this research by using questionnaires as described in Chapter 3. The quantitative data provided a means to obtain a rich description of how practicals are carried out in this particular school, and attempted to quantify students' perceptions so comparisons could be made. The data also gave a detailed view of the context so that qualitative data could subsequently be better interpreted.

The qualitative data gave insights into students' perceptions with regards to practicals and how they are carried out. As students completed the questionnaire, they had to state their opinions and preferences depending on the question asked. Subsequently qualitative data were also obtained from the students' respective teachers through of interviews. This was done to obtain a clearer picture of why practical activities are carried out the way they are, and whether students and teachers perceive practicals differently. The results in the form of tables and figures are presented and analysed in this chapter, however the full results can be found in Appendix 5.

## 4.2 Description of the Respondents

The investigation was carried out in a co-educational independent school in Malta. All students participated in the study so therefore the student population was equal to the number of respondents. The distribution of students by grade and gender is shown in Table 4.1.

**Table 4.1: Students by Grade and Gender**

	Boys	Girls	Total
<b>Grade 8</b>	45	37	<b>82</b>
<b>Grade 9</b>	47	29	<b>76</b>
<b>Grade 10</b>	39	34	<b>73</b>
<b>Grade 11</b>	39	36	<b>75</b>
<b>Grade 12</b>	42	31	<b>73</b>
<b>Total</b>	<b>212</b>	<b>167</b>	<b>379</b>

Grade 8 had the biggest number of students (82) with the other grades having roughly the same number of students (73 to 76). There were more boys than girls in all grades with the biggest discrepancy being in Grade 9 (61.8% boys) and the smallest in Grade 11 (52%).

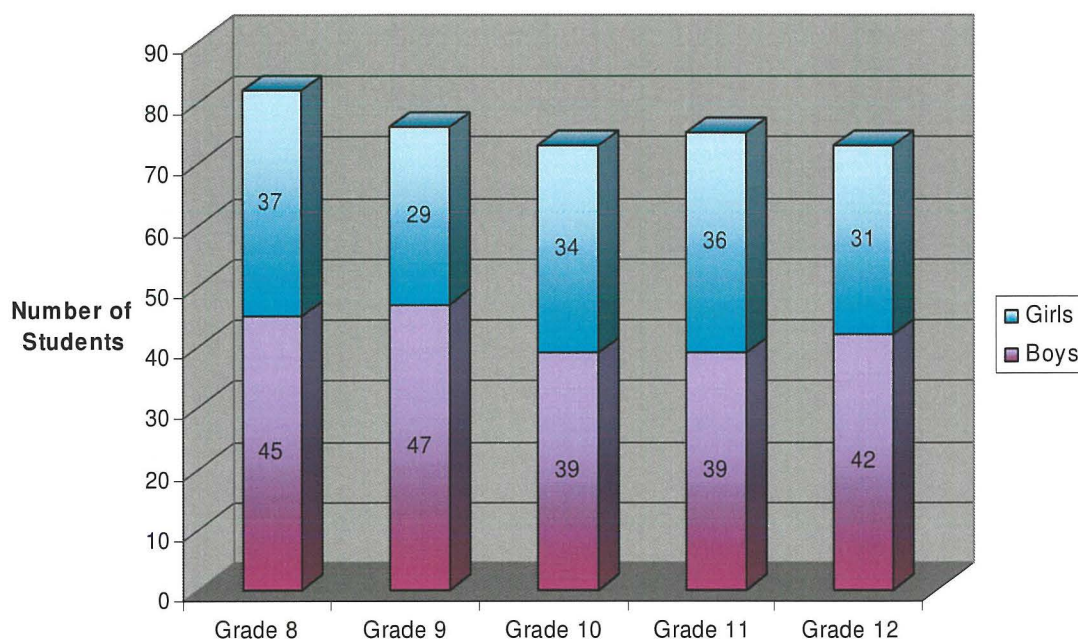


Figure 4.1: Number of students by Grade and Gender

All Grade 8 and 9 students study General Science, while the three sciences (Biology, Chemistry and Physics) are offered from Grade 10. Students may opt to study one, two or all three science subjects as can be seen in Table 4.2:

Table 4.2: Subject combinations chosen by Grade (Grades 10-12)

	Grade 10	Grade 11	Grade 12	Total
<b>Biology Only</b>	15	8	18	<b>41</b>
<b>Chemistry Only</b>	0	0	0	<b>0</b>
<b>Physics Only</b>	23	29	24	<b>76</b>
<b>Biology - Chemistry</b>	7	4	5	<b>16</b>
<b>Biology - Physics</b>	3	11	5	<b>19</b>
<b>Chemistry - Physics</b>	5	2	2	<b>9</b>
<b>All Three</b>	20	21	19	<b>60</b>

'Physics Only' (34.4%) was the most selected option followed by 'All Three' (27.1%) and 'Biology Only' (18.6%). 'Biology – Physics' (8.6%), 'Biology – Chemistry' (7.2%) and 'Chemistry – Physics' (4.1%) rounded off the list. No students selected 'Chemistry Only'. Figure 4.2 shows the percentage of students taking each subject combination in each grade.

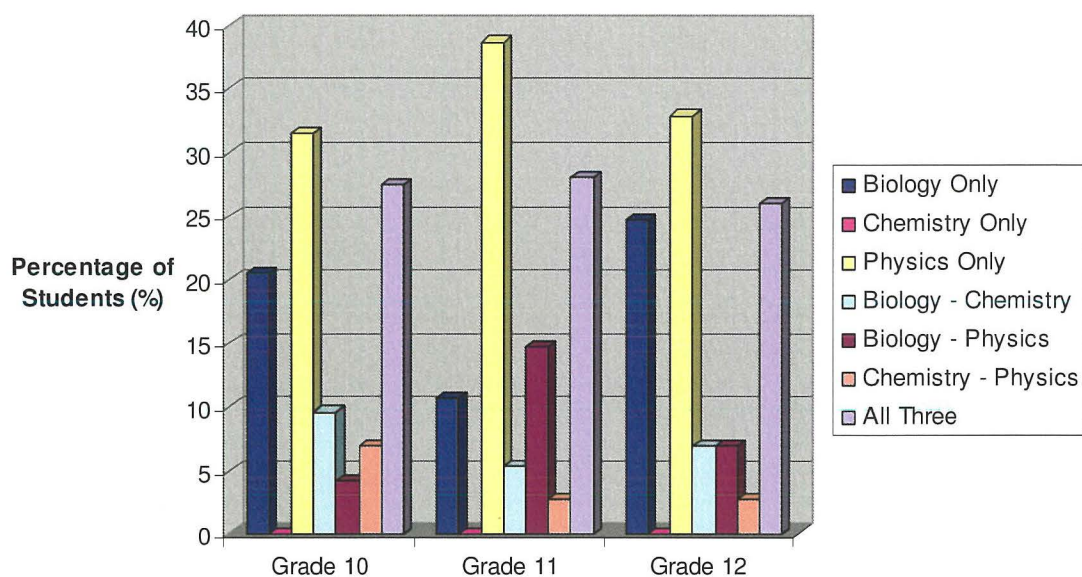


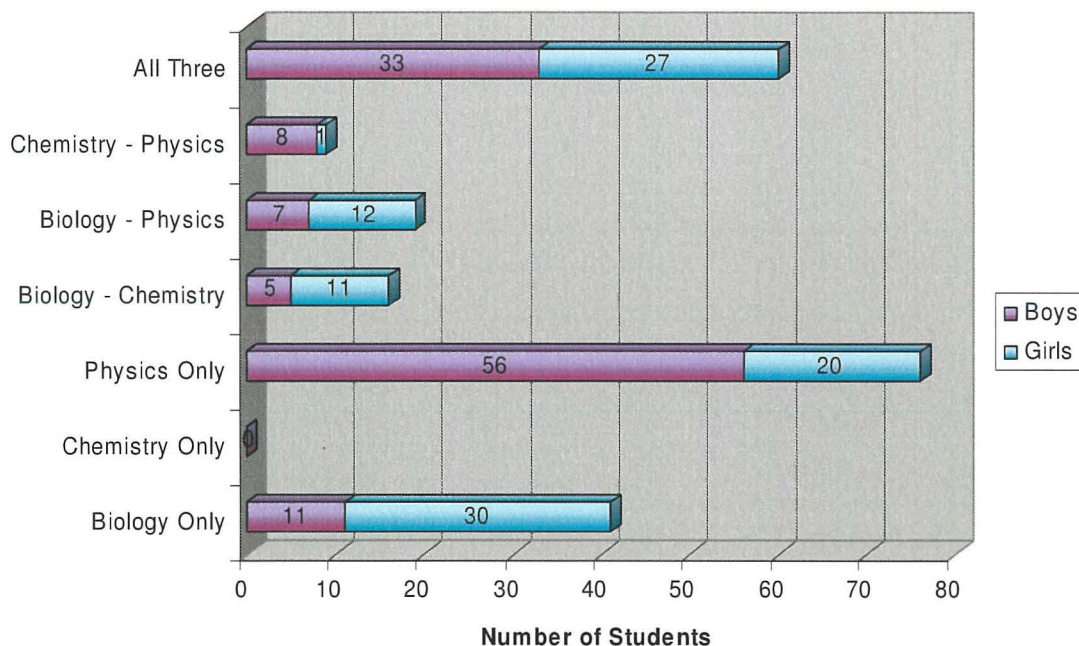
Figure 4.2: Percentage of Subject combinations chosen by Grade

Table 4.3 gives a breakdown of each subject combination by gender.

Table 4.3: Subject combinations chosen by Gender (Grades 10-12)

	Boys	Girls	Total
<b>Biology Only</b>	11	30	<b>41</b>
<b>Chemistry Only</b>	0	0	<b>0</b>
<b>Physics Only</b>	56	20	<b>76</b>
<b>Biology - Chemistry</b>	5	11	<b>16</b>
<b>Biology - Physics</b>	7	12	<b>19</b>
<b>Chemistry - Physics</b>	8	1	<b>9</b>
<b>All Three</b>	33	27	<b>60</b>

'Physics Only' (46.7%) was the preferred subject combination of boys followed by 'All Three' (27.5%) and 'Biology Only' (9.2%). Girls on the other hand inverted the first and third choices preferring 'Biology Only' (29.7%) followed by 'All Three' (26.7%) and 'Physics Only' (19.8%) as seen in Figure 4.3.



**Figure 4.3: Subject combinations chosen by Gender (Grades 10-12)**

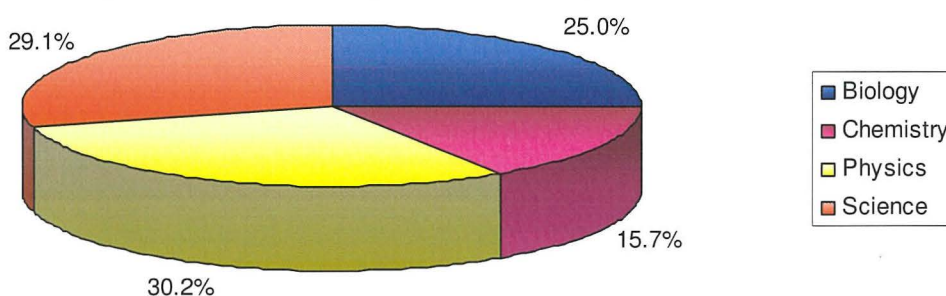
The number of students studying each subject (Biology, Chemistry, Physics) was analysed by grade and gender (Table 4.4) and trends were noted.

**Table 4.4: Number of students studying each subject irrespective of combination analysed by Grade and Gender (Grades 10-12)**

		Grade 10	Grade 11	Grade 12	Total
<b>Biology</b>	<b>Boys</b>	18	17	21	<b>56</b>
	<b>Girls</b>	27	27	26	<b>80</b>
	<b>Total</b>	<b>45</b>	<b>44</b>	<b>47</b>	<b>136</b>
<b>Chemistry</b>	<b>Boys</b>	19	14	13	<b>46</b>
	<b>Girls</b>	13	13	13	<b>39</b>
	<b>Total</b>	<b>32</b>	<b>27</b>	<b>26</b>	<b>85</b>
<b>Physics</b>	<b>Boys</b>	32	37	35	<b>104</b>
	<b>Girls</b>	19	26	15	<b>60</b>
	<b>Total</b>	<b>51</b>	<b>63</b>	<b>50</b>	<b>164</b>

When looking at the number of students studying each subject irrespective of combination, Physics (42.6%) was the most popular subject followed by Biology (35.3%) and Chemistry (22.1%). This order was maintained in all grades. The same order was followed when looking at the number of male students taking each option with Physics (50.5%) again being the most popular, followed by Biology (27.2%) and Chemistry (22.3%). In the case of female students, Biology (44.7%) was the most popular followed by Physics (33.5%) and Chemistry (21.8%).

As it was possible that a student would take more than one subject, each reply by subject was seen individually and counted as an individual response. Therefore, if a student studied Biology and Physics [for example,] he or she would have responded the same question for each individual subject and therefore counted as two responses. So even though the actual number of respondents was 379, the number of individual responses was 543 (the 221 Grade 10 to 12 students actually contributing 385 individual replies). So the overall percentage of responses by subject was as shown in Figure 4.4:



**Figure 4.4: Percentage of responses by Subject**

All five (of the) science teachers at the school (with the exception of myself) were interviewed. These included a General Science teacher, a Biology teacher, a Chemistry teacher and two Physics teachers.

### 4.3 Importance given to Practical Work

Bennett (2005) said that the prominence of practicals in the school science curricula of many countries suggests that there is a clear commitment on the part of both teachers and others involved in science education to the contribution that practicals make to science lessons.

When the teachers were asked about the importance given to practicals, there were some contrasting views. Some of them mentioned that the fact that they directly influenced the MATSEC mark meant that students give them a lot of importance:

*“Because it makes up fifteen percent of the MATSEC mark, it is given a lot of importance ... much more than any other piece of homework.”*

(Physics teacher)

However the Chemistry teacher took a general outlook at practicals as he said:

*“Well, I think in general not too much importance is given to practical work more specifically in Chemistry because of the fact that the practicals just stick to the facts which are covered in the syllabus rather than enforce particular skills. Probably there should be room for more.”*

(Chemistry teacher)

#### 4.4 The Reasons for doing Practical Work

Various authors (e.g. Millar et. al, 1999; Wellington, 2002; Hofstein and Lunetta, 2003) have written about the reasons for doing practicals as seen in Chapter 2. In this particular study both students and teachers spoke favourably about practicals and mentioned numerous reasons why it is carried out.

A large portion of students said that experiments were carried out *“to learn how something is done”* (Grade 8, boy) and to help them understand the concepts learnt in class better:

*“To learn and understand things more easily by actually seeing them.”*

(Grade 10 Biology, girl)

As well as teaching them the relevance of science to real life:

*“To prove that what is studied in books is relevant to real life.”*

(Grade 12 Chemistry, girl)

In addition, the Grade 8 students (31.7%) and Grade 9 students (22.4%) mentioned that practicals allow them to see how things work. Interestingly, there was a large difference in percentage between Grade 9 girls (41.4%) and boys (10.6%) as more girls said this.

*“To show us how stuff works and to understand more about what's happening around us.”*

(Grade 9, girl)

A few of the younger students also mentioned that experiments were done to have fun. Amongst other responses students mentioned that experiments were done to prove what they had already learnt, to learn how to handle apparatus and to get hands-on experience:

*“To prove what the teachers say and make sure the teachers are not lying.”*  
(Grade 10 Physics, girl)

*“To get first hand experience and help us understand what we are doing in theory better.”*  
(Grade 12 Biology, girl)

*“So that we can witness the reactions between chemicals.”*  
(Grade 10 Chemistry, boy)

Some students claimed that experiments helped them by being easier to remember:

*“Easier to remember physical properties rather than just read about them.”*  
(Grade 12 Chemistry, girl)

A few students also mentioned that practicals allow them to be like real scientists and the activity is seen to be beneficial for their future:

*“To find out things and follow the footsteps of other scientists.”*  
(Grade 10 Chemistry, boy)

*“Practicals are done so that you can see things for yourself and if you become a scientist you would have some personal experience.”*  
(Grade 11 Chemistry, boy)

From Grade 10 onwards, MATSEC examinations became an issue and a few students from each grade mentioned that experiments were done because of their SEC-level exam:

*“To become accustomed with the lab equipment, to practice what we study, to have marks in MATSEC from your coursework. Science must be proved so theory without practice won't make sense.”*  
(Grade 12 Chemistry, boy)

The responses indicate that the school under study values practicals and it seems that science teachers do manage to convey their reasons for doing practicals to the students as teachers endorsed the reasons given by the students:

*“It supports what is being done in theory.”*  
(Physics teacher)

*“It gives them hands-on experience and makes them familiar with the actual apparatus.”*  
(Physics teacher)

*“They’re seeing it actually happening and they understand better.”*

(Physics teacher)

*“It basically serves as an eye opener of what is said in class.”*

(Chemistry teacher)

*“They learn practical skills such as handling scientific equipment, being able to do particular routines in an accurate fashion and experiencing and carrying about rules that conform with safety.”*

(Chemistry teacher)

*“They get to see how scientists found and got to know the knowledge that we have today.”*

(Biology teacher)

Looking at the responses it seems that for the majority of both students and teachers, the reasons that come to mind for doing practicals are related to the connection they perceive between the activity and the subject content. Other reasons such as social goals and using practicals as a coping strategy (as mentioned by Swain et. al., 1999) were not seen as principal reasons. Only the General Science teacher gave reasons other than understanding and acquisition of knowledge as she mentioned that *“students learn how to work in teams, they also learn how to discuss experiments and they should realise that science is not just about theory it’s about practical work.”* This may be because in the lower grades (8 and 9) the focus is not on content but on the acquisition of skills and teachers are meant to teach science through practicals (Science Syllabus Grades 8 and 9).

Therefore, one may conclude that the main arguments given in favour of doing practicals by students and teachers are the cognitive, the affective and the skills arguments mentioned by Wellington (2002).

#### **4.4.1 Practical Work: An Aid for Understanding**

In a pilot project by CERG (Chemical Education Research Group, 2005), it was noted that teachers had differing opinions about whether practicals help conceptual understanding. Therefore in this study students were asked whether they thought the experiments helped them understand the subject better. The replies were similar as seen in Tables 4.5 and 4.6. Please note that when looking at the responses of the higher grades, the responses were

sorted by subject chosen besides grade since students could have different views of the practicals based on the subject studied.

**Table 4.5: Do you think experiments help you understand the subject better? (Science Students)**

	Grade 8 (n = 81)			Grade 9 (n = 76)			Science Totals (n = 157)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
<b>A</b>	44	35	<b>79</b>	41	27	<b>68</b>	85	62	<b>147</b>
<b>B</b>	0	1	<b>1</b>	1	0	<b>1</b>	1	1	<b>2</b>
<b>C</b>	1	0	<b>1</b>	5	2	<b>7</b>	6	2	<b>8</b>

**Key for Table 4.5**

**A** - Yes, they help me

**B** - No, they do not help me

**C** - Do not affect learning of the subject

**Table 4.6: Do you think experiments help you understand the subject better? (Grades 10-12)**

	Biology (n=135)				Chemistry (n=83)				Physics (n=159)			
	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total
<b>A</b>	41	40	36	<b>117</b>	27	25	22	<b>74</b>	42	58	42	<b>142</b>
<b>B</b>	1	1	3	<b>5</b>	0	1	0	<b>1</b>	3	1	3	<b>7</b>
<b>C</b>	3	3	7	<b>13</b>	3	1	4	<b>8</b>	2	4	4	<b>10</b>

**Key for Table 4.6**

**A** - Yes, they help me

**B** - No, they do not help me

**C** - Do not affect learning of the subject

Most students (89.9%) replied that the experiments helped them understand the subject better with only 2.8% saying that they did not help. A small portion of the population (8.8%) said they did not affect the learning of the subject. Therefore, most students seem to find experiments helpful as they aid their understanding of the subject. This is also confirmed by the General Science teacher who hopes “to achieve better understanding of the science subject” and by a Physics teacher who said that she thinks “it’s very good because they understand the theory much more”.

Thus, one can conclude that according to the students, the practicals conducted in this school help students understand the subject more.

#### 4.4.2 Practical Work: An Aid for Performing Better in Examinations

The Physics SEC Examiners' report (2007) claims that:

*“It is a well-known fact among all educators that first hand experience does not only enhance the students’ enjoyment of the lesson but it also helps understanding of the concepts and allows for their interlinking.”*

(p.3)

This “well-known fact” was investigated when the students were asked whether they felt they performed better in examinations because of practicals. Tables 4.7 and 4.8 show the responses obtained:

**Table 4.7: Do you feel that you will perform better in exams because you did practical work? (Science Students)**

	Grade 8 (n = 82)			Grade 9 (n = 74)			Science Totals (n = 156)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
<b>A</b>	41	33	<b>74</b>	38	26	<b>64</b>	79	59	<b>138</b>
<b>B</b>	4	4	<b>8</b>	8	2	<b>10</b>	12	6	<b>18</b>

**Key for Table 4.7**

**A - Yes      B - No**

**Table 4.8: Do you feel that you will perform better in exams because you did practical work? (Grades 10-12)**

	Biology (n=135)				Chemistry (n=83)				Physics (n=158)			
	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total
<b>A</b>	34	37	32	<b>103</b>	20	23	20	<b>63</b>	33	54	37	<b>124</b>
<b>B</b>	10	7	15	<b>32</b>	10	4	6	<b>20</b>	13	9	12	<b>34</b>

**Key for Table 4.8**

**A - Yes      B - No**

Most students (80.5%) thought that they performed better in examinations because of practicals with only 19.5% thinking otherwise. This reasoning was mirrored across all grades and subjects with no differences based on gender noticed (apart from the fact that all Grade 12 Physics female students replied ‘Yes’). Grade 10 Chemistry and Grade 12 Biology students gave the lowest number of ‘Yes’ responses with 66.7% and 68.1% respectively. This means that a 32.3% of Chemistry students and 39.9% of Biology students said that practicals do not help them in examinations.

When asked to give reasons for their responses, a large number of the students who said 'Yes' replied that the experiments were easier to remember during an examination than the theory done in class:

*"Because when you do something it sticks in your brain."*

(Grade 9, boy)

*"You remember the practical more than when you study because you would have done it yourself."*

(Grade 11 Physics, boy)

They also helped students understand the concepts better which in turn helped during an examination. Some noted that questions about experiments were often asked during exams:

*"It will help me for any questions given about them in the exam."*

(Grade 10 Physics, girl)

*"Because in exams they always ask questions regarding practical work."*

(Grade 12 Chemistry, girl)

*"Experiments show us that what we learned is correct and we get to design an experiment in our MATSEC exam."*

(Grade 11 Physics, boy)

Those who replied 'No' mostly felt that the experiments took time away from more theory or explanation time and found them more of a distraction with no direct benefit for an examination:

*"Because if something is explained, doing it is just repeating the explanation."*

(Grade 10 Physics, boy)

Others thought that having practicals increased the amount of work they had to study:

*"Because there's more work to study."*

(Grade 8, boy)

Even though most students believed that practicals did help them in their examinations, this view was not shared by all their teachers as one can see below:

*“Considering the way our exams are set it doesn’t really make a difference whether you’ve actually seen an ammeter or not before in your life.”*

(Physics teacher)

*“Some of them might. The people who usually have good visual memory certainly do, because they would remember particular facts. Probably not every one does though.”*

(Chemistry teacher)

*“Yes they do, they do help. Even to describe, if they have to describe an experiment once they have done it, they are able to describe it more easily.”*

(Physics teacher)

*“Yes it does help them ... but some students find it difficult to relate the theory to practical.”*

(General Science teacher)

*“Yes they can, and they do in fact.”*

(Biology teacher)

Teachers’ differing opinions about whether experiments help students in examinations was also noted by Xuereb (1996), whereby in his study he found that most teachers thought that students who do well in practicals, either do well in the final examination (41.7%) or just as well as other students (45%), while 13.3% expected them to do worse.

Likewise, in this study most students seem adamant that practicals help them in examinations, an opinion not shared by all of their respective teachers. Given that a lot of time has to be set aside to do experiments and to write the report, I think it is reasonable for students to think that practicals should be of help. If the experiments do not help students in examinations it is rational that some students might think that *“it’s a waste of time that should be spent on theory”* (Grade 12 Biology, boy) especially in later grades where students are preparing to sit for their SEC examinations.

The SEC Biology, Chemistry and Physics examination papers (2007) in fact did contain a number of questions about experiments and the respective SEC syllabi were clear about what was expected (refer to Chapter 2). The Chemistry SEC Examiners’ report (2007) stated *“It was a pleasure to see that the students drew on their experimental observations in the lab”* (p.7) while on the contrary the Biology SEC Examiners’ report (2007) when referring to questions about practical work reported that *“Answers were generally poor and*

not of SEC level standard” (p.11). Similarly the Physics SEC Examiners’ report (2007) stated that:

*“Candidates seem to lack direct experience in using apparatus and sometimes show that they may not even have seen the experiment being done let alone handling it themselves ... Students gain a sound grasp over the topics and their performance in examinations should show this.”*

(p.3)

Therefore here it is evident that MATSEC examiners do expect practicals to help students in their examinations. For this reason it is important that both students and teachers are aware of this; teachers need to improve their methodology and students need to give experiments more importance.

Research carried out by Nott and Wellington (1999) on investigations found that the General Certificate of Secondary Education (GCSE) grade obtained by the students is linked to how straightforward they found investigations. In fact, the higher the GCSE grade the more likely that investigations were seen as straightforward.

#### **4.5 The Effect of MATSEC on Requirements on Practical Work**

Teachers were asked whether having MATSEC request that students present reports and therefore do experiments restricted them in anyway. In general, none of the teachers found it restricting. However, there were certain things that they did find restricting: the Biology teacher mentioned time as a restricting factor as he claimed the syllabus is too vast and he would like to dedicate more time to experiments. One Physics teacher found the marking scheme restrictive in that the mark is out of fifteen. The Chemistry teacher on the other hand said that outings are not recognised unless the students have covered the fifteen experiments required. He also complained about the investigative experiments listed in the syllabus and said that *“they’re a bit too conservative for being investigative practicals”*. The teachers mentioned that they would like marking criteria to come out of MATSEC. This was also reported by Xuereb (1996) in earlier research:

*“The only thing I would want from MATSEC is a marking criteria that comes out from MATSEC not one which I have to do.”*

(Physics teacher)

The Chemistry teacher also mentioned that the practical skills demonstrated during practicals are not assessed:

*“Assessment doesn’t take in consideration what the student does in class. Consequently there are students who are getting away with making a mess in the lab but because they’re good at writing they can get away with it because they can present a very high quality report.”*

(Chemistry teacher)

#### 4.6 Student Satisfaction with the Amount of Practical Work Done

Given that students seem to value practicals, I was intrigued as to whether students were satisfied with the number of practicals done. Therefore, students were asked how many practicals were carried out within the first term (October to December) and whether the number of practicals carried out was enough. Figure 4.5 illustrates the number of practicals carried out in the five grades between October and December.

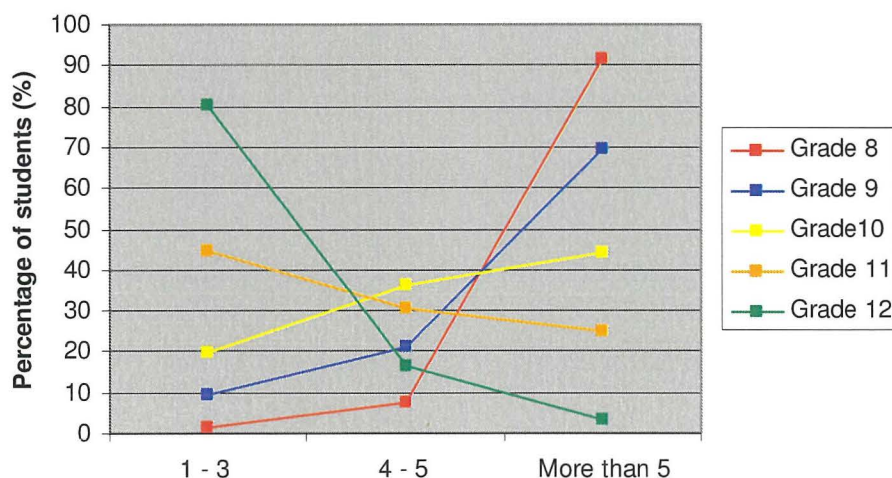


Figure 4.5: Amount of practical work per Grade

Taking a general overview of the five grades together, it can be seen that less practicals are carried out as students go up in grade. The difference in number of practicals stated by students may be due to different classes moving at a different pace (e.g. due to holidays or ability) or they were absent or simply because the students forgot how many they had. Looking at students’ responses grade by grade, the students in Grades 8 and 9 answered as shown in the Tables 4.9 and 4.10.

**Table 4.9: The amount of practical work done between October and December for General Science students**

	Grade 8 (n = 82)			Grade 9 (n = 75)			General Science (n = 157)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
<b>A</b>	0	1	<b>1</b>	5	2	<b>7</b>	5	3	<b>8</b>
<b>B</b>	5	1	<b>6</b>	10	6	<b>16</b>	15	7	<b>22</b>
<b>C</b>	40	35	<b>75</b>	31	21	<b>52</b>	71	56	<b>127</b>

**Key for Table 4.9**  
**A** - 1 to 3      **B** - 4 to 5      **C** - More than 5

**Table 4.10: General Science students' satisfaction with the amount of practical work done**

	Grade 8 (n = 81)			Grade 9 (n = 75)			General Science (n = 156)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
<b>A</b>	12	5	<b>17</b>	18	3	<b>21</b>	30	8	<b>38</b>
<b>B</b>	30	32	<b>62</b>	27	22	<b>49</b>	57	54	<b>111</b>
<b>C</b>	2	0	<b>2</b>	1	4	<b>5</b>	3	4	<b>7</b>

**Key for Table 4.10**  
**A** - Too little      **B** - Enough      **C** - Too many

The General Science teacher confirmed that many practicals are carried out “*basically every lesson*” and therefore considers it to be enough. Likewise the majority of both Grade 8 (76.5%) and Grade 9 students (65.3%) considered the number of practicals done to be ‘Enough’, followed by those thinking they had ‘Too little’ (21% and 28% respectively). Only a small minority in both grades (2.5% and 6.7%) thought they had ‘Too many’. Given that both Grade 8 (91.5%) and Grade 9 (69.3%) students had on average more than five experiments, it would seem that General Science students are quite happy with the large number of practicals done.

As regards responses based on gender, both sexes followed the same pattern of opinion with the only exception being the Grade 9 females, where a slightly higher percentage of girls (13.8%) thought they had ‘Too many’ practicals as opposed to 10.3% who thought they had ‘Too little’. It was also noted that an overwhelming majority of females thought they had ‘Enough’ practicals (81.1%) as compared to 63.3% of males (33.3% of males wanting more). This may imply that while both sexes seem pleased with the amount of practicals done, given the option more males than females would opt to have more. The fact that they want more may imply that they enjoy them. Females seem to enjoy practicals less and this confirms literature (Kelly, 1981). The issue of enjoyment was another point investigated and will be discussed in Section 4.8.

The questions were repeated to the higher grades to see whether responses differed depending on subject and grade. Tables 4.11 and 4.12 present the responses obtained for Grades 10 to 12.

**Table 4.11: The amount of practical work done between October and December divided by Subject and Grade**

	<b>Biology</b> ( <i>n</i> =135)				<b>Chemistry</b> ( <i>n</i> =83)				<b>Physics</b> ( <i>n</i> =158)			
	Grade 10	Grade 11	Grade 12	<b>Total</b>	Grade 10	Grade 11	Grade 12	<b>Total</b>	Grade 10	Grade 11	Grade 12	<b>Total</b>
<b>A</b>	4	10	33	<b>47</b>	16	24	22	<b>62</b>	4	25	43	<b>72</b>
<b>B</b>	14	20	12	<b>46</b>	11	1	4	<b>16</b>	19	19	4	<b>42</b>
<b>C</b>	27	13	2	<b>42</b>	3	2	0	<b>5</b>	24	18	2	<b>44</b>

**Key for Table 4.11**  
**A** - 1 to 3      **B** - 4 to 5      **C** - More than 5

**Table 4.12: Satisfaction with amount of practical work done divided by Subject and Grade**

	<b>Biology</b> ( <i>n</i> =136)				<b>Chemistry</b> ( <i>n</i> =83)				<b>Physics</b> ( <i>n</i> =159)			
	Grade 10	Grade 11	Grade 12	<b>Total</b>	Grade 10	Grade 11	Grade 12	<b>Total</b>	Grade 10	Grade 11	Grade 12	<b>Total</b>
<b>A</b>	5	4	0	<b>9</b>	3	6	1	<b>10</b>	6	10	2	<b>18</b>
<b>B</b>	29	32	42	<b>103</b>	23	21	23	<b>67</b>	30	46	45	<b>121</b>
<b>C</b>	11	8	5	<b>24</b>	4	0	2	<b>6</b>	12	7	1	<b>20</b>

**Key for Table 4.12**  
**A** - Too little      **B** - Enough      **C** - Too many

Even though results showed that there was a significant difference in the number of practicals carried out depending on subject and grade, when the students were asked whether they were satisfied with the number of practicals carried out, the results were similar across the board in that nearly all students indicated they were pleased with the number of practicals done. This is highlighted in Figure 4.6:

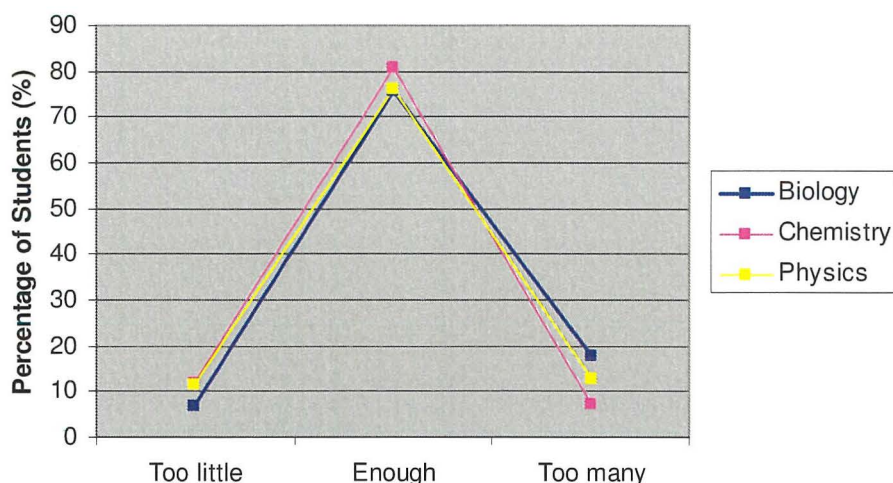


Figure 4.6: Satisfaction with the amount of practical work done in the three sciences

The number of practicals carried out by Biology students decreased gradually when going to higher grades. This was confirmed by the Biology teacher who said that out of the 20 to 22 practicals done over a period of three years, only two practicals were carried out in Grade 12. The Biology teacher said that ideally there should be more practicals:

*“The syllabus is so vast that unfortunately the practicals are sometimes seen as an extra burden on the workload which shouldn’t be the case because the teacher should have enough time to go through the practicals with students, not just about enough to get through to MATSEC.”*

(Biology teacher)

The students regardless of subject responded that they were pleased with the amount of practicals done in all grades suggesting that as the students grow older, their need and want for practicals diminished.

As regards gender, there was no major difference in opinion as illustrated in Figure 4.7.

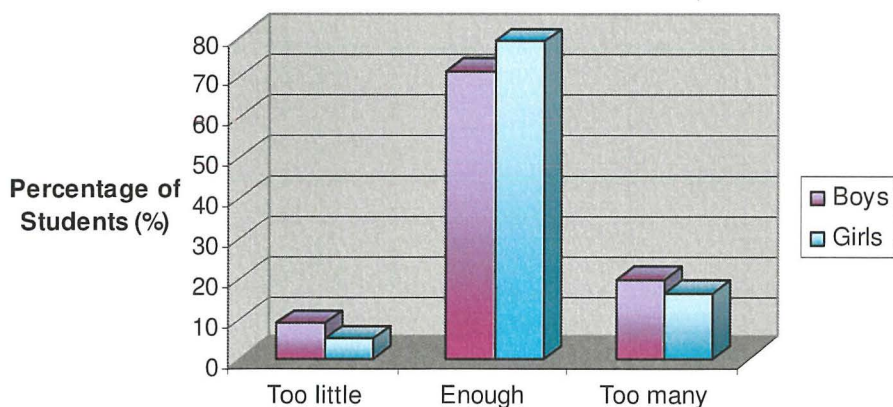
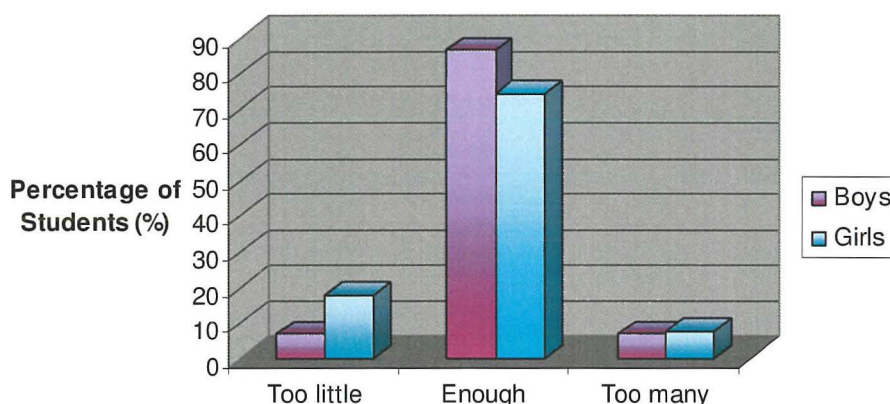


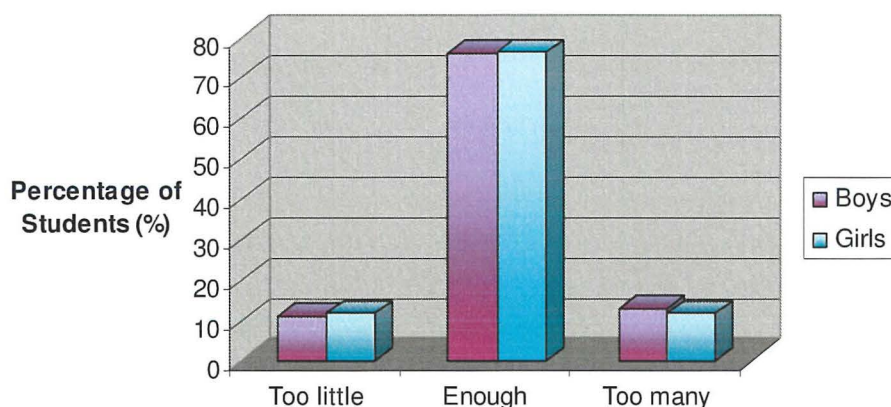
Figure 4.7: Satisfaction with the amount of practical work done by Gender in Biology

While the Chemistry teacher said that practicals were carried out every fifteen days or so, a big majority of the Chemistry students (74.7%) irrespective of grade said that they had between one to three practicals in the first term. This, coupled with the fact that an even greater majority (80.7%) said they had enough practicals seems to indicate that Chemistry students enjoy their practicals less than the other science students. The Chemistry teacher said that he would like to increase the number of practicals but thought that the current number to be sufficient. Considering gender, 6.8% of the boys and 17.9% of the girls who studied Chemistry considered the amount of practicals done to be 'Too little' and 86.4% of the boys and 74.4% of the girls said that enough practicals are being done as illustrated in Figure 4.8. This seems to imply that more girls than boys would opt to have more practicals carried out in Chemistry.



**Figure 4.8: Satisfaction with the amount of practical work done by Gender in Chemistry**

Physics students responded roughly in the same manner as Biology students to both questions. While the number of practicals carried out again decreased for higher grades (though there was a sharper drop from Grade 10 to 11) the students found the number done to be enough across all grades. The Physics teachers confirmed that the number decreased from Grade 10 to 11 with only one experiment being done in Grade 12. One of the teachers noted that the number of practicals done depended on the topic, for example, more experiments being carried out for optics than linear motion. There were practically no gender differences in the responses given by Physics students as shown in Figure 4.9.



**Figure 4.9: Satisfaction with the amount of practical work done by Gender in Physics**

This indicates that most boys and girls are content with the amount of practicals carried out in Physics.

#### 4.7 Students' Perceptions of the Difficulty of Practical Work as they Progress Academically

It may be tempting to assume that as students progress from one grade to the other the practicals carried out become more complex and therefore more difficult. To this end, Grade 8 and 9 students were asked whether they perceive experiments as being difficult.

**Table 4.13: Are the tasks given during your experiment difficult? (Science Students)**

	Grade 8 (n = 81)			Grade 9 (n = 75)			Science Totals (n = 156)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
<b>A</b>	1	0	1	1	1	2	2	1	3
<b>B</b>	1	1	2	4	4	8	5	5	10
<b>C</b>	17	18	35	16	11	27	33	29	62
<b>D</b>	19	17	36	20	10	30	39	27	66
<b>E</b>	6	1	7	5	3	8	11	4	15

**Key for Table 4.13**

**A** - Always      **B** - Often      **C** - Sometimes      **D** - Rarely      **E** - Never

Both the Grade 8 and 9 students responded that the tasks given were only 'Sometimes' (39.7%) or 'Rarely' (42.3%) difficult. The low number of respondents replying 'Always' or 'Often' seems to indicate that overall students found the level of difficulty acceptable and not too taxing. No big difference in opinion based on gender was noticed since the answers followed mostly the same pattern. However it should be noted that overall, male students seemed to find the level of difficulty slightly easier than their female counterparts.

Students in the higher grades were also asked whether they find experiments difficult and their responses were divided by subject as shown in Table 4.14.

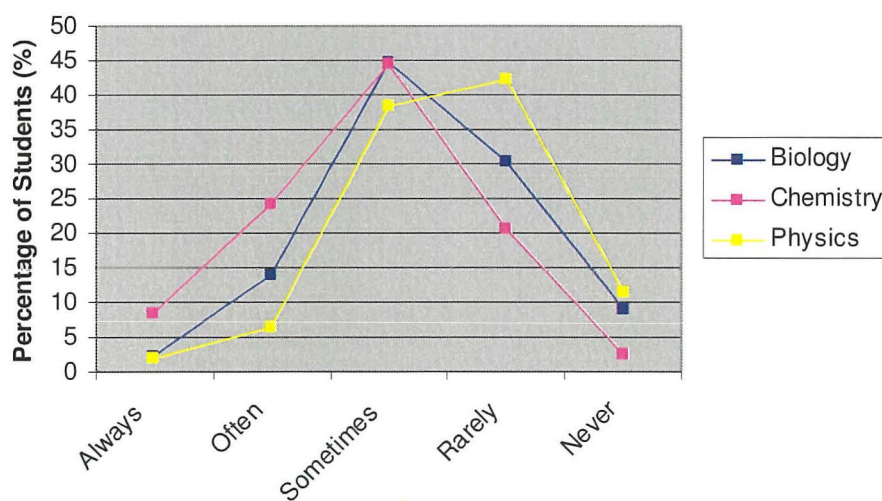
**Table 4.14: Are the tasks given during your experiment difficult? (Grades 10-12)**

	Biology ( <i>n</i> =136)				Chemistry ( <i>n</i> =83)				Physics ( <i>n</i> =159)			
	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total
<b>A</b>	1	2	0	<b>3</b>	3	2	2	<b>7</b>	0	2	1	<b>3</b>
<b>B</b>	3	6	10	<b>19</b>	7	8	5	<b>20</b>	4	3	3	<b>10</b>
<b>C</b>	18	22	21	<b>61</b>	11	13	13	<b>37</b>	17	31	13	<b>61</b>
<b>D</b>	16	12	13	<b>41</b>	8	3	6	<b>17</b>	21	20	26	<b>67</b>
<b>E</b>	7	2	3	<b>12</b>	1	1	0	<b>2</b>	5	7	6	<b>18</b>

Key for Table 4.14				
A - Always	B - Often	C - Sometimes	D - Rarely	E - Never

While replies between grades remained mostly constant within the same subject, when comparing subjects a difference was noted between the separate sciences as shown in Figure 4.10.



**Figure 4.10: Perception of difficulty by Subject**

While both Biology and Chemistry students responded that they sometimes find the tasks difficult, when looking at the spread between the subjects it can be clearly seen that Chemistry students found the tasks to be difficult more often than Biology students. On the other hand Physics students rarely found the tasks difficult and found the tasks even easier than the Biology students. This seems to imply that the Chemistry experiments are seen as the most difficult by the students followed by the Biology experiments, Physics

being the easiest. When it comes to gender, as opposed to the Grade 8 and 9 students, Grade 10-12 females seemed to find the practicals easier overall than males as shown in Figure 4.11.

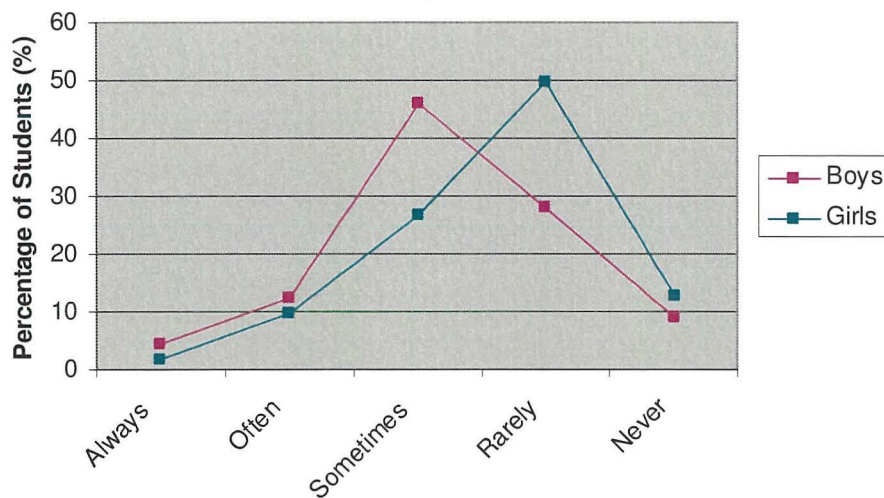


Figure 4.11: Perception of difficulty by Gender

This was also found true within Biology and Physics where females in all grades seemed to find experiments easier. On the contrary however, male Chemistry students seem to find practicals easier than females as a higher percentage of females marked the 'Always', 'Often' and 'Sometimes' categories.

Next, students were asked whether the difficulty of practicals changed as they progressed from one grade to the next. In order to answer this query, students were asked whether the difficulty of practicals changed over the years and, if yes, whether the practicals became more difficult or not. For the Grade 8 students, since this was their first year doing practicals, they were told to comment whether practicals became more difficult over the course of the year.

Table 4.15: Does the difficulty of practical work change over the years? (Science Students)

	Grade 8 ( <i>n</i> = 82)			Grade 9 ( <i>n</i> = 76)			Science Totals ( <i>n</i> = 158)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
<b>A</b>	13	13	<b>26</b>	28	17	<b>45</b>	41	30	<b>71</b>
<b>B</b>	32	24	<b>56</b>	19	12	<b>31</b>	51	36	<b>87</b>

Key for Table 4.15

A - Yes

B - No

Table 4.16: If yes, in what way? (Science Students)

	Grade 8 (n = 26)			Grade 9 (n = 45)			Science Totals (n = 71)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
<b>A</b>	7	8	<b>15</b>	15	11	<b>26</b>	22	19	<b>41</b>
<b>B</b>	6	5	<b>11</b>	13	6	<b>19</b>	19	11	<b>30</b>

**Key for Table 4.16**

A - More difficult

B - Less Difficult

Here the replies were not very conclusive since out of the students who noted a change in difficulty, there was not a general consensus as to whether the practicals become more or less difficult (though Grade 9 students noticed a bigger change and leaned more towards more difficult). No big discrepancies by gender were noticed. The General Science teacher says that the difficulty between Grade 8 and 9 “changes slightly but it is adapted to their level”. However, when it came to Grade 10-12 students, a clearer picture was obtained as shown in Tables 4.17 and 4.18.

Table 4.17: Does the difficulty of practical work change over the years? (Grades 10-12)

	Biology (n=136)				Chemistry (n=83)				Physics (n=159)			
	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total
<b>A</b>	29	37	32	<b>98</b>	21	20	23	<b>64</b>	34	44	40	<b>118</b>
<b>B</b>	16	7	15	<b>38</b>	9	7	3	<b>19</b>	13	19	9	<b>41</b>

**Key for Table 4.17**

A - Yes

B - No

Table 4.18: If yes, in what way? (Grades 10-12)

	Biology (n=98)				Chemistry (n=64)				Physics (n=118)			
	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total
<b>A</b>	27	33	26	<b>86</b>	19	20	22	<b>61</b>	31	39	35	<b>105</b>
<b>B</b>	2	4	6	<b>12</b>	2	0	1	<b>3</b>	3	5	5	<b>13</b>

**Key for Table 4.18**

A - More difficult

B - Less Difficult

In all of the subjects, more than half the students noticed an increase in difficulty as the years go by. Of these the majority in each subject said that they found the difficulty increasing in later years. The Chemistry teacher confirmed what the students said:

*“In Grade 10 students have to grasp simple facts or to reinforce, and there is handling of rather simplistic equipment. In Grade 11 more accurate skills are required. Then in Grade 12 students have to do qualitative things so they have to be extra careful.”*

These thoughts were echoed by the Physics teachers: *“As students get older there is more referring to graphs and finding the gradient. The application also gets harder.”* Very few said the difficulty decreased (highest being just 12.2% in Biology). This is in line with what the Biology teacher said, *“...practicals basically don’t have an escalating difficulty as such, but we do tend to work with the topics which are easier to understand in the earlier grades”*. As regards gender, again no difference in opinion between the sexes was noted.

#### 4.8 Factors that make Experiments Enjoyable or not for Students

The next set of questions tried to determine whether the students enjoyed their practicals and the factors behind such enjoyment. They also tried to find out whether the practicals of a particular subject were enjoyed more than others, as can be seen in Tables 4.19 and 4.20.

**Table 4.19: Do you enjoy practical work? (Science Students)**

	Grade 8 (n=81)			Grade 9 (n=76)			Science Totals (n=157)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
<b>A</b>	0	0	<b>0</b>	2	2	<b>4</b>	2	2	<b>4</b>
<b>B</b>	0	1	<b>1</b>	3	0	<b>3</b>	3	1	<b>4</b>
<b>C</b>	1	1	<b>2</b>	2	3	<b>5</b>	3	4	<b>7</b>
<b>D</b>	10	6	<b>16</b>	16	13	<b>29</b>	26	19	<b>45</b>
<b>E</b>	34	28	<b>62</b>	24	11	<b>35</b>	58	39	<b>97</b>

**Key for Table 4.19**

A - No

B - A little

C - Indifferent

D - Quite

E - A lot

When asked whether they enjoyed practicals, the replies of the Science students were mostly positive with the majority replying ‘A lot’ (61.8%) or ‘Quite’ (28.7%). It was however noted that the level of enjoyment seemed to diminish slightly from Grade 8 to 9 with a decrease in those replying ‘A lot’ (46.1% from 76.5%) and four students replying ‘No’. Grade 9 females in particular expressed a bigger decrease in enjoyment.

Table 4.20: Do you enjoy practical work? (Grades 10-12)

	Biology ( <i>n</i> =136)				Chemistry ( <i>n</i> =83)				Physics ( <i>n</i> =159)			
	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total
<b>A</b>	1	3	6	<b>10</b>	4	1	5	<b>10</b>	3	3	10	<b>16</b>
<b>B</b>	2	4	7	<b>13</b>	0	1	4	<b>5</b>	1	1	5	<b>7</b>
<b>C</b>	7	6	6	<b>19</b>	4	1	4	<b>9</b>	2	6	5	<b>13</b>
<b>D</b>	16	15	23	<b>54</b>	10	13	5	<b>28</b>	18	30	18	<b>66</b>
<b>E</b>	19	16	5	<b>40</b>	12	11	8	<b>31</b>	23	23	11	<b>57</b>

**Key for Table 4.20**

A - No

B - A little

C - Indifferent

D - Quite

E - A lot

The same pattern was observed for the Grade 10 to 12 students where the number replying ‘A lot’ decreased steadily from 46.1% in Grade 9 to only 19.7% in Grade 12. This seems to indicate an overall decrease in enjoyment as the years go by. However there was still a positive response overall with the majority of students replying ‘Quite’ (Grades 11 and 12) and ‘A lot’ (Grade 10). Figure 4.12 shows the level of enjoyment by grade.

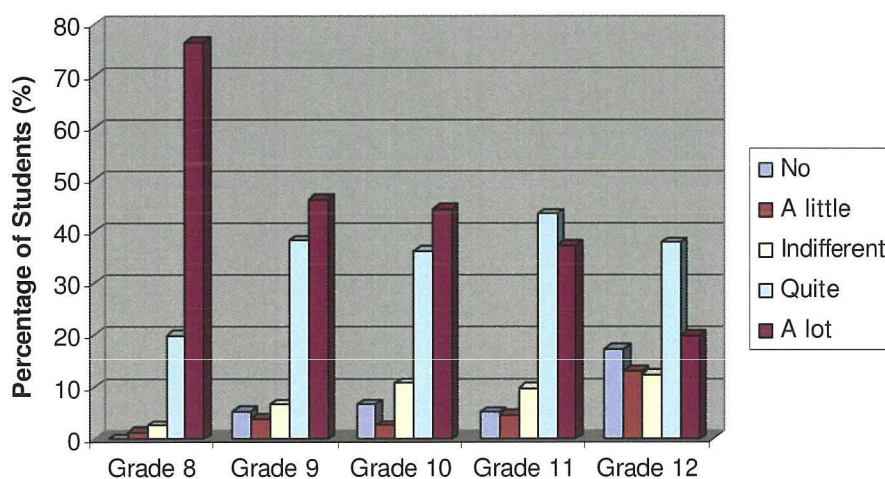
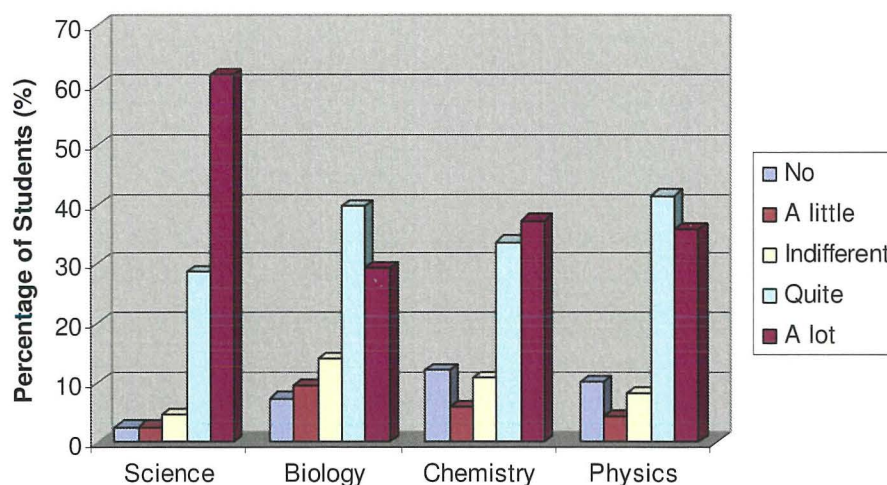


Figure 4.12: Level of enjoyment of practical work by Grade

While Physics students seem to enjoy their practicals most overall with 77.3% of them replying ‘A lot’ or ‘Quite’ (as opposed to 71% for Chemistry and 69.1% for Biology), Biology had the lowest number of students saying they did not like practicals. Grade 12 Physics practicals were the least popular with 20.4% replying ‘No’. As regards gender, no conclusive differences between sexes could be noted with no particular subject being preferred by a particular gender across all grades. This differs from Kelly’s study (1981) that showed that internationally boys had a greater liking for, and interest in, practicals.



**Figure 4.13: Level of enjoyment of practical work by Subject**

When asked for reasons for their level of enjoyment of practicals, students within all grades and subjects gave similar responses. A large number of students who replied positively said that they enjoyed them because they had fun doing them:

*“It’s a lot of fun and we could learn things which could be useful for when we grow up.”*

(Grade 8, boy)

*“They are always entertaining! Much more interesting than an actual lesson.”*

(Grade 11 Biology, girl)

*“These are both usually interesting and quite fun.”*

(Grade 12 Chemistry, girl)

A small number also mentioned that practicals help them learn and that they gave them a break from writing:

*“Because at least you do other things instead of just writing.”*

(Grade 9, boy)

*“Because it gives you a break from the writing and listening and it’s fun to do.”*

(Grade 11 Physics, girl)

Some of the older students said that they find them interesting while others mentioned that enjoyment arose from sometimes getting surprising results. Chemistry students mentioned that they like *“working with chemicals and discovering new substances”* (Grade 10 Chemistry, girl).

*“Unexpected things happen e.g. electrolysis.”*

(Grade 11 Chemistry, boy)

However, Chemistry students also pointed out the difficulty of the experiments with a number of female students stating they were *“scared of doing something wrong”*.

*“I am usually scared that I am going to do something wrong.”*

(Grade 10 Chemistry, girl)

This is in line with the Erickson and Farkas report (1987) that female students' negative responses to science tasks were related to their lack of confidence and fear of handling practical equipment such as Bunsen Burners and electrical circuits. They blame the lack of prior informal experiences for females' inferior performance in Physics and Chemistry. Murphy (1994) further reports that boys are better than girls in using hand lenses and stop clocks at all ages and microscopes, force meters, ammeters and voltmeters at ages 13 and 15.

Students also mentioned that they enjoy working with friends. Amongst those that replied negatively some said that they do not like the fact that they do not choose their partners for practicals:

*“Because it's good working with friends and handling chemicals.”*

(Grade 10 Biology, girl)

*“We don't choose who we are with.”*

(Grade 10 Chemistry, girl)

When it came to those who replied negatively, an overwhelming number of students seemed to find writing the report the main stumbling block in their enjoyment. While most students enjoyed the actual experiment, report writing was far less popular, with students from each grade and subject mentioning it as the main reason for not making an experiment enjoyable.

*‘It's ok but I hate knowing that I have to write a long report.’*

(Grade 12 Biology, girl)

*“I don't really enjoy doing chemistry practical reports because they are too long, we have too little time to do them and no good explanation given.”*

(Grade 10 Chemistry, girl)

*“The practicals are fun however the prospect of having to do a long report afterwards ruins it a little.”*

(Grade 11 Chemistry, girl)

Biology students complained that most of the experiments were fairly similar and the results not that exciting:

*“All the same, nothing exciting.”*

(Grade 11 Biology, boy)

*“They become boring.”*

(Grade 12 Biology, girl)

Some students said that experiments were a waste of time (especially Physics students), though interestingly this was mentioned as a good thing by some and a bad thing by others.

A student who said this is what she likes about practicals:

*“It wastes time from the lesson and it’s more hands-on.”*

(Grade 12 Chemistry, girl)

Another student who said this is what he does not like about practicals:

*“Because I find it a waste of time. It is better that we study instead.”*

(Grade 12 Biology, boy)

Students were further asked what they liked about experiments and the answers greatly resembled those given above. Yet a few also mentioned how they enjoyed using apparatus, with three boys specifically mentioning the Bunsen burner while a number of girls said that “we get messy” (Grade 9, girl):

*“We do different things each time, but I enjoy using the Bunsen burner.”*

(Grade 8, boy)

One Grade 11 boy also said how “you do something and be proud of it”. Some students mentioned the fact that they found the break from normal lessons refreshing (preferring hands-on work to the normal lesson) while:

*“Moving about and not sitting down on a chair but studying the subject differently.”*

(Grade 10 Biology, girl)

*“Get involved and doing hands-on work.”*

(Grade 11 Physics, boy)

Finally students were asked what they did not like about practicals. While quite a number of students said there was nothing they did not like about practicals, once again the most common reason for not liking practicals across all grades was the report writing (especially the accuracy and detail required) which was mentioned by a big majority of the students:

*“Writing the report, it makes my wrist ache.”*

(Grade 8, girl)

Cleaning up was also listed regularly while one female student mentioned being *“stuck with partners for the rest of the year”* (Grade 8, girl).

Physics students complained about the *“the short amount of time given”* (Grade 10 Physics, girl) to complete the experiments and that *“sometimes what we are trying to find is very vague”* (Grade 12 Physics, girl).

Some Chemistry students were critical of the explanations given by their teacher during experiments.

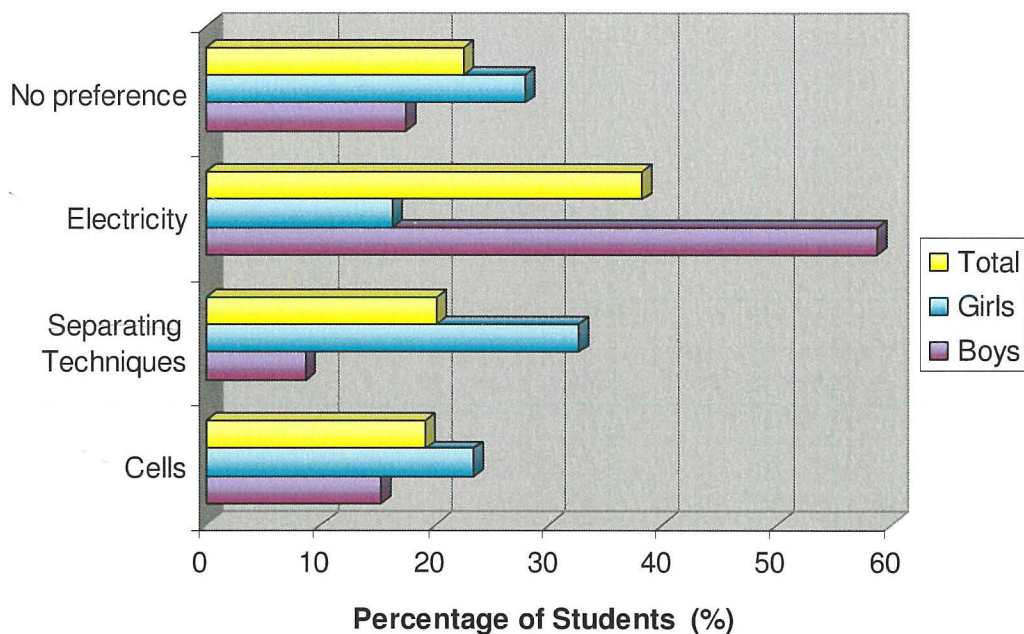
*“Everything, as explanation is never given well.”*

(Grade 11 Chemistry, girl)

Therefore it seems that most students like the practical itself but not the report which comes after. Considering this, students were asked whether they prefer some experiments over others.

#### **4.8.1 Preference of Particular Experiments**

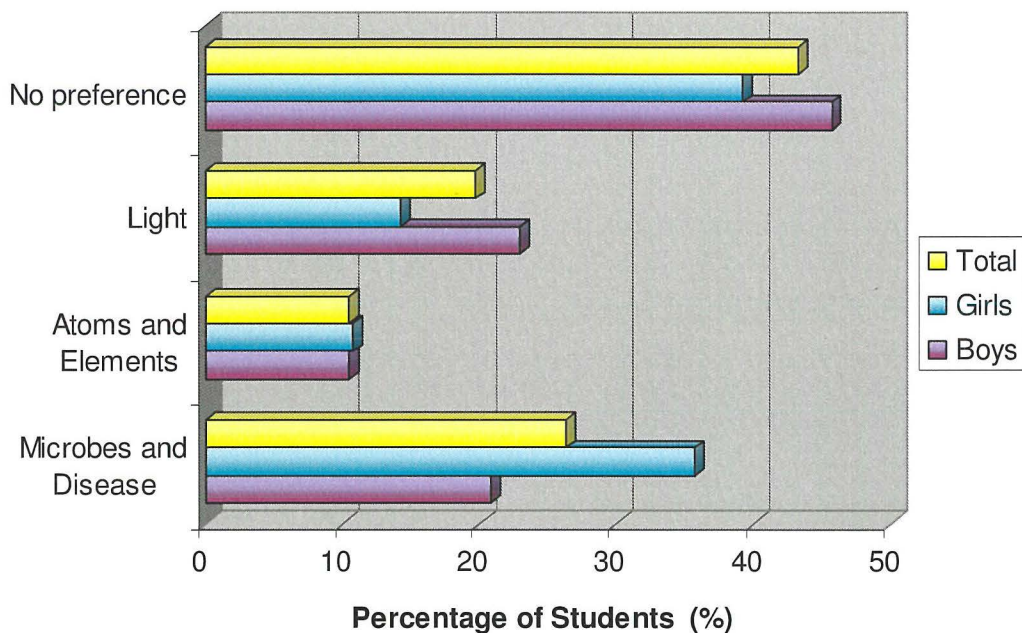
The next question was aimed at seeing whether Science students preferred a particular type of experiment over another. Students had to tick which practical they preferred from the experiments they had covered by the time the questionnaire was administered. Grade 8 students answered as shown in Figure 4.14:



**Figure 4.14:** The experiment preference of Grade 8 students

Excluding those who stated 'no preference' (22.5%), a clear distinction here was noticed between the sexes for each topic choice. This was particularly obvious with 'Electricity' which was a big favourite with male students (58.7%) but not with females (16.3%) where it was in fact the least preferred. 'Separating Techniques' experiments were the most popular with females (32.6%) and the least popular with males (8.7%). Therefore, it seems that in Grade 8 the boys and the girls have opposing views on which experiments they prefer. It may be interesting to investigate the factors of each particular topic which boys and girls find intriguing.

Such drastic opposite views were not seen by the Grade 9 students as shown in Figure 4.15.



**Figure 4.15: The experiment preference of Grade 9 students**

Most of the Grade 9 students said that they do not have any preference (43.4%), which seems to indicate that they enjoy the experiments of each topic equally. However, excluding those who stated ‘no preference’, most female students preferred ‘Microbes and Disease’ (35.7%) while males preferred ‘Light’ (22.9%). Experiments of ‘Atoms and Elements’ were the least favourite (10.5%) amongst both sexes.

These findings are similar to Whitelegg’s (1996) findings in which she reported that the topics selected by boys and girls tended to follow the girls-and-biology/boys-and-physics pattern. This polarisation of choices, with girls having a stronger preference for the biological sciences than boys, indicates a split along traditional gender lines. The distribution of preference of experiments is likely to influence subject choice and if one looks at the pattern of subject choice in Grades 10, 11 and 12 (in Section 4.2) one may note that in all grades more boys choose Physics whereas more girls choose Biology. It may be interesting to see whether practicals were an influential factor. Ormerod (1981) found that ‘liking of practical work’ was a significant discriminator for boys in all three science subject choices, in that it was an added incentive to study science. However, liking practicals was not the main incentive to study science for girls.

For the Grade 10 to 12 students, a different question was put forward, this time to determine which, if any, of the science subject practicals were the most popular.

Table 4.21: Which Science subject practicals do you prefer? (Grades 10-12)

	Grade 10 ( <i>n</i> = 125)			Grade 11 ( <i>n</i> = 134)			Grade 12 ( <i>n</i> = 123)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
<b>A</b>	3	11	<b>14</b>	14	12	<b>26</b>	14	16	<b>30</b>
<b>B</b>	13	14	<b>27</b>	11	10	<b>21</b>	6	13	<b>19</b>
<b>C</b>	10	8	<b>18</b>	5	18	<b>23</b>	12	8	<b>20</b>
<b>D</b>	23	8	<b>31</b>	17	11	<b>28</b>	11	0	<b>11</b>
<b>E</b>	19	16	<b>35</b>	21	15	<b>36</b>	26	17	<b>43</b>

**Key for Table 4.21**

A - Those of Biology

B - Those of Chemistry

C - Those of Physics

D - No preference

E - Only study one Science subject

Excluding those who had ‘no preference’ and those who studied only one science subject, Biology experiments were the most popular overall (70%), followed closely by Chemistry (67%) and Physics (61%) experiments. However looking at the results by grade a difference is noticed between Grade 10 where Chemistry experiments were the most popular and the later grades where they were the least popular. While Biology experiments were the most popular in the last two grades, they were the least favourite in Grade 10. Physics experiments were the second most popular across all grades. Looking at the same figures by gender male students were less enthusiastic with Biology experiments in Grade 10, Physics experiments in Grade 11 and Chemistry experiments in Grade 12. Meanwhile female students stated they preferred those subjects which fared poorly with males. Therefore while there is a difference of preference between the sexes when looking at the results grade by grade, there is not a particular trend with a specific subject, with preferences changing over the years. These findings are different from the findings of Murphy (1994) who said that girls’ interests were in biological and medical applications and boys’ were in physics applications.

#### 4.9 Factors that make a Good Experiment

Franklin (1981) states that the factors that would make an experiment ‘good’ would include ability of an experiment to illustrate its relationship to existing theories, or call for new theories, and the ability of the apparatus to measure the quantities of interest to sufficient accuracy and precision. Feynman (1992) believes that a good experiment does not need to have a profound result or influence. It does not need to be important or even

necessarily interesting. He believes that a good experiment needs to be well-controlled and reproducible. Scientists will almost always learn something in the process of a good experiment. But even if they do not, they should know why. Most of all he believes that a good experiment has to be honest:

*"...It's a kind of scientific integrity, a principle of scientific thought that corresponds to a kind of utter honesty -- a kind of leaning over backwards. For example, if you're doing an experiment, you should report everything that you think might make it invalid -- not only what you think is right about it; other causes that could possibly explain the results; and things you thought of that you've eliminated by some other experiment, and how they worked to make sure the other fellow can tell they have been eliminated."*

(Feynman 1992, p.341)

This question was put to both the students and the teachers so that I could learn their views in this area. Interestingly, boys and girls did not differ in their responses as to what makes a good practical. The main factors that make a good experiment according to the students were:

- it has to be fun, interesting and/or exciting;
- it must help in understanding the theory better;
- the instructions should be clear and easy to understand and follow;
- a good explanation by the teacher;
- good apparatus must be provided;
- safety must be assured;
- good results obtained;
- experiment must be performed by the students themselves.

In the early grades (8 and 9), the experiment being fun was the most mentioned factor (42% and 26.2% respectively). Whilst students of all grades mentioned this factor it was interesting to note that this factor was mentioned less in higher grades. Female students were also noted to mention it more than males.

*“Something that is fun and which is easy to understand and remember.”*

(Grade 8, girl)

Higher grade students tended to mention the experiment being interesting and exciting more as opposed to fun, a trait particularly noticed with Chemistry students where a good number mentioned handling of dangerous chemicals and substances as a main factor.

*“Colourful and explosive reactions.”*

(Grade 10 Chemistry, boy)

The experiment helping in understanding the theory better was also a factor mentioned more frequently in the lower grades as opposed to the higher grades. Easy to understand and follow instructions, accompanied by a good explanation by the teacher was a factor mentioned throughout all grades and subjects.

*“Giving clear instructions, obtaining a good result and learning from it.”*

(Grade 11 Biology, girl)

Having good apparatus was also considered important, it was interesting to note however that no Chemistry students mentioned it, only Science, Biology and Physics students did.

*“Safety, guidance, fun and the good apparatus.”*

(Grade 9, boy)

*“Good explanation, good apparatus to carry out the experiment.”*

(Grade 12 Biology, boy)

Finally, good results became an important factor from Grade 10 onwards (no mention by the Science students), particularly for Biology and Physics students.

This question was also posed to the teachers during the interviews. Teachers answered the question similarly to the students indicating that teachers' values have been passed on to the students. The General Science teacher said that having good instructions is very important and that the students follow those instructions. The Biology teacher mentioned that the students had to understand what the investigation was about and that they had to be very clear about the method. It was also important that they knew how to interpret the results. The Chemistry teacher said that there had to be concrete aims for the experiments and that the experiments themselves should be as varied as possible. He mentioned that the students had to achieve particular skills and learn particular concepts through the experiments. He was also the only one to mention the importance of the experiment being

well-timed. Finally the Physics teacher placed particular importance on the results obtained (mirroring what her students said),

*“... that the graph really comes out as a straight line and they can see the relationship between one thing and the other”.*

She also placed importance in the inventiveness and improvisation of the students saying

*“... letting them even come up with their own apparatus, apparatus which might not even be lab apparatus. That is the ideal practical.”*

#### 4.10 Feeling like a Scientist

For many, one of the first images that comes to mind when thinking about science is a laboratory filled with people in white coats busy with various sorts of apparatus (Halliday and Martin, 1993). From this image some believe that:

*“experiments in science classrooms are designed to illustrate the way in which scientists work.”*

(Halliday and Martin, 1993, p.183)

Students within this school were asked whether they felt like scientists when doing experiments and their reasons for this were also investigated by this questionnaire.

**Table 4.22: Do you feel like a real scientist when doing experiments? (Science Students)**

	Grade 8 (n = 81)			Grade 9 (n = 74)			Science Totals (n = 155)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
<b>A</b>	23	26	<b>49</b>	19	15	<b>34</b>	42	41	<b>83</b>
<b>B</b>	22	10	<b>32</b>	28	12	<b>40</b>	50	22	<b>72</b>

**Key for Table 4.22**

A - Yes      B - No

**Table 4.23: Do you feel like a real scientist when doing experiments? (Grades 10-12)**

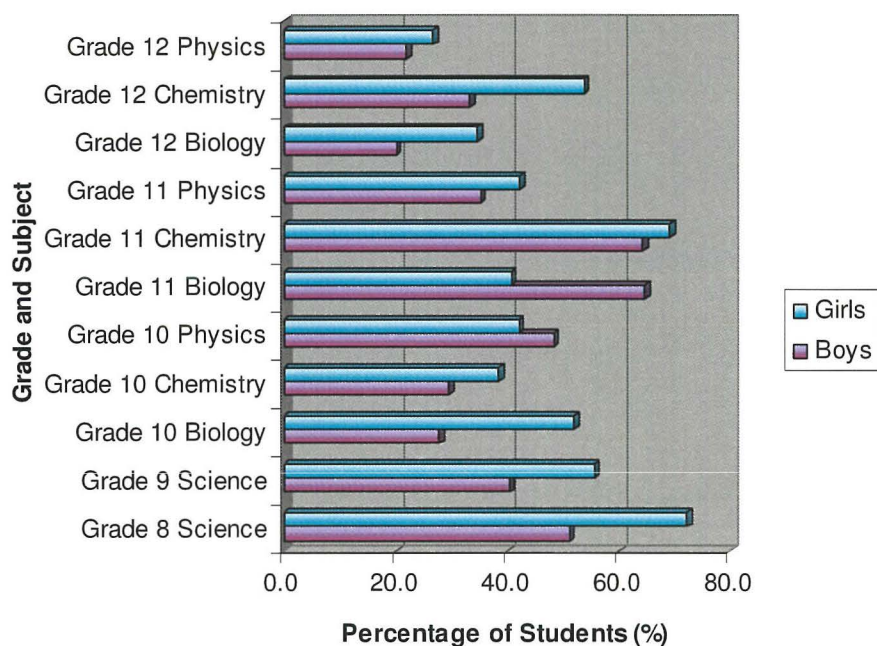
	Biology (n=135)				Chemistry (n=82)				Physics (n=158)			
	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total
<b>A</b>	19	22	13	<b>54</b>	10	18	11	<b>39</b>	22	24	11	<b>57</b>
<b>B</b>	26	22	33	<b>81</b>	20	9	14	<b>43</b>	26	39	36	<b>101</b>

**Key for Table 4.23**

A - Yes      B - No

It resulted that out of all the grades, only Grade 8 had a majority of students (60.5%) replying that they felt like scientists during the experiments, with all the other grades replying mostly no. In fact except for Grade 11 (47.8% as opposed to 41.5% in Grade 10), there was a gradual decrease in 'Yes' responses when going to higher grades. Looking at the subjects individually, only the Science students replied 'Yes' overall (this being mostly made up of the aforementioned Grade 8 students). As regards the higher grades, Chemistry seemed to make the students feel like scientists most as 47.6% replied 'Yes', as opposed to 40% for Biology and 36.1% for Physics the lowest percentage across all subjects.

Of particular interest, when looking at the results obtained based on gender, females replied 'Yes' more than males in all grades and subjects with the only exceptions being Grade 11 Biology (40.7% of females replying 'Yes' as opposed to 64.7% of males) and Grade 10 Physics (42.1% versus 48.3%). This is illustrated in Figure 4.16:



**Figure 4.16: Percentage of students who feel like real scientists when doing experiments by Gender**

Taking a look at the replies irrespective of grade and subject, while only 39.6% of boys felt like real scientists during the experiments, nearly half the girls (49.2%) said they felt so.

When analysing the reasons students gave for feeling like real scientists during experiments, the main reason reported by students was the wearing of lab coats and goggles.

*“Wearing a lab coat, goggles etc. makes me keener to learn experiments.”*  
(Grade 8, girl)

A large proportion of Physics students complained that *“we don't wear lab coats or goggles (real characteristics of a scientist)”* (Grade 12 Physics girl) and that *“the teacher doesn't let us feel like one”* (Grade 12 Physics girl). This may be the reason why a large proportion of the Physics students said that they do not feel like a scientist when doing experiments.

Other reasons given for feeling like a scientist included the fact that they were doing an experiment and solving something. For some students this made them feel intelligent which is a trait usually associated with scientists.

*“Because I have to find out the kind of mystery.”*  
(Grade 8, boy)

*“Since they are complicated it makes me feel smart when completing it.”*  
(Grade 11 Chemistry, girl)

Some students feel they are following in the footsteps of real scientists when doing experiments. As one student pointed out:

*“When doing a practical, one is put into a scientist's shoes.”*  
(Grade 11 Chemistry, boy)

*“We retrace steps of scientists and are transported back in time to do an experiment for the first time.”*  
(Grade 11 Biology, girl)

Also mentioned were “being in a laboratory” and “using apparatus”

*“It is scientific and cannot be done anywhere.”*  
(Grade 10 Chemistry, boy)

*“We are in a laboratory, carrying out an experiment and taking safety measures.”*  
(Grade 12 Physics, girl)

*“The method usually reminds me of really scientific stuff. Like mixing chemicals and observing slides under a microscope.”*  
(Grade 12 Biology, girl)

*"I use chemicals and become familiar with apparatus I don't usually use."*  
(Grade 12 Biology, girl)

On the other hand the main reasons given by students for not feeling like real scientists seemed to concentrate on the fact that they were following instructions and not making up the experiment themselves. This is mentioned especially because they are given step-by-step instructions:

*"Because it is like doing an experiment that someone found out before you anyway."*  
(Grade 8, boy)

*"To be a real scientist you have to study a lot and you wouldn't need a teacher."*  
(Grade 8, girl)

*"We are in a secondary school that is extremely guided and students are not at liberty to perform alone!"*  
(Grade 12 Biology, girl)

Students also mentioned the fact that they had nothing new to prove, just confirming a previous theory seemed to play a part:

*"People have done the experiments before you. Nothing new to find out there!"*  
(Grade 12 Physics, girl)

*"We are told and the teacher already knows more or less what our results are going to be."*  
(Grade 12 Physics, girl)

These findings are similar to those of Nott and Wellington (1999) in which the vast majority of students involved in their study complained that practicals were really *make* "pretend" since they already knew the answers and had done similar things before. This was also pointed out by Jenkins (1999).

Some students believed that the experiments they performed were too short and easy for real scientists as one boy pointed out *"we're cutting onions half the time"* (Grade 12 Biology, boy). Students seem to think that scientists do complicated experiments with exciting results:

*“Because they are a bit too simple to feel like a real scientist.”*

(Grade 8, boy)

*“Because scientists do much cooler stuff like blowing something up.”*

(Grade 9, boy)

A number of students do not see their experiment and results as being important:

*‘Even though we are doing an experiment it’s not as important as the other experiments.’*

(Grade 9, girl)

Students pointed out that *“a scientist is a person that practices certain practicals that help him in his job and not to pass an exam!”* (Grade 12 Physics, boy)

Students also seem to think that scientists have better equipped laboratories and better apparatus.

*“I’m not professional and nor are the labs.”*

(Grade 10 Biology, girl)

*“Because we don’t use good apparatus.”*

(Grade 10 Physics, boy)

*“We need later technology.”*

(Grade 10 Biology, boy)

These findings seem to indicate that though experiments may be carried out regularly, they are not enough for students to be introduced to the world of scientists (as mentioned in Chapter 2) by actually doing practicals the scientific way (Woolnough and Allsop, 1985). Most students picture scientists doing activities very different from what they do during practical activities which may be caused by the images they receive from the media and they are not all together wrong in thinking like this. Woolnough and Allsop (1985) state that:

*“The fact that all students do not always show this motivation to act as enquiring scientists in school laboratories may indicate more about the artificial and inhibiting nature of school science lessons than about the students’ lack of scientific potential. Our aim, therefore, to develop the scientist in the student should be seen as a general educational rather than a vocational one.”*

(p. 32)

Teachers however agree that the practicals done in class are related to the experiments carried out by professionals as *“the students are taught to make a connection between simple apparatus, investigating a particular aspect compared to the industrial apparatus”* (Biology teacher). This is backed by the General Science teacher’s comment that *“when it comes to basic techniques, yes, they are related”*. The Chemistry teacher also notes that *“one of the aims in class is actually to pass the message to the kids that ‘listen, this is being done in the industry’”*. The Physics teacher points out that the main difference between professionals and students is that *“professionals do experiments without knowing what the end result is going to be. In our case, I know exactly where I want to lead the students so I know what the final result is”*. This is unlike what Hofstein and Lunetta (2003) stated that many teachers do not perceive that helping students understand how scientific knowledge is developed and used in the scientific community is an especially important goal of laboratory activities for their students.

#### 4.11 The Instructions given for Practical Work

Giving instructions is a very important aspect of the practical work as understanding them or not will have either positive or negative consequences on the experiment. Students were asked questions to determine their understanding of what went on during practicals and whether they found the instructions given to be easy to understand and how they could be improved. Tables 4.24 and 4.25 show how Science students responded when asked whether they understood the aim and what went on during a practical session:

**Table 4.24: Do you understand the aim when you are doing an experiment? (Science Students)**

	Grade 8 (n = 100)			Grade 9 (n = 76)			Science Totals (n = 176)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
<b>A</b>	31	11	<b>42</b>	15	13	<b>28</b>	46	24	<b>70</b>
<b>B</b>	21	17	<b>38</b>	20	10	<b>30</b>	41	27	<b>68</b>
<b>C</b>	11	8	<b>19</b>	9	4	<b>13</b>	20	12	<b>32</b>
<b>D</b>	0	1	<b>1</b>	0	2	<b>2</b>	0	3	<b>3</b>
<b>E</b>	0	0	<b>0</b>	3	0	<b>3</b>	3	0	<b>3</b>

**Key for Table 4.24**

**A** - Always

**B** - Often

**C** - Sometimes

**D** - Rarely

**E** - Never

**Table 4.25: Do you understand what's happening during the experiment? (Science Students)**

	Grade 8 ( <i>n</i> = 82)			Grade 9 ( <i>n</i> = 76)			Science Totals ( <i>n</i> = 158)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
<b>A</b>	21	13	<b>34</b>	18	9	<b>27</b>	39	22	<b>61</b>
<b>B</b>	21	19	<b>40</b>	18	16	<b>34</b>	39	35	<b>74</b>
<b>C</b>	3	5	<b>8</b>	7	2	<b>9</b>	10	7	<b>17</b>
<b>D</b>	0	0	<b>0</b>	1	0	<b>1</b>	1	0	<b>1</b>
<b>E</b>	0	0	<b>0</b>	3	2	<b>5</b>	3	2	<b>5</b>

**Key for Table 4.25**

A - Always    B - Often    C - Sometimes    D - Rarely    E - Never

Students overall seemed to have a good understanding of both the aim and what went on during an experiment with the majority of answers given being 'Always' and 'Often' (39.2% and 42.5% respectively overall). 'Sometimes' was ticked by a small percentage (14.7%) with only a few replying 'Rarely' and 'Never'. Replies were fairly uniform across both grades and gender (though it should be noted that eleven out of the twelve students who replied 'Rarely' and 'Never' were Grade 9 students). This is different from the study by Ekici, (2002, as cited by Yildiz et al. 2006) in which he found that females have a more positive attitude towards the aims of science experiments and of the science laboratory than males.

Tables 4.26 and 4.27 show the responses obtained from the Grade 10 to Grade 12 students.

**Table 4.26: Do you understand the aim when you are doing an experiment? (Grades 10-12)**

	Biology ( <i>n</i> =136)				Chemistry ( <i>n</i> =83)				Physics ( <i>n</i> =158)			
	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total
<b>A</b>	15	15	17	<b>47</b>	10	16	7	<b>33</b>	19	20	30	<b>69</b>
<b>B</b>	24	16	18	<b>58</b>	9	6	11	<b>26</b>	22	33	9	<b>64</b>
<b>C</b>	5	11	10	<b>26</b>	6	3	6	<b>15</b>	5	9	6	<b>20</b>
<b>D</b>	0	2	0	<b>2</b>	3	1	1	<b>5</b>	0	1	2	<b>3</b>
<b>E</b>	1	0	2	<b>3</b>	2	1	1	<b>4</b>	1	0	1	<b>2</b>

**Key for Table 4.26**

A - Always    B - Often    C - Sometimes    D - Rarely    E - Never

Table 4.27: Do you understand what's happening during the experiment? (Grades 10-12)

	Biology ( <i>n</i> =136)				Chemistry ( <i>n</i> =84)				Physics ( <i>n</i> =157)			
	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total
<b>A</b>	17	14	20	<b>51</b>	10	11	7	<b>28</b>	28	22	21	<b>71</b>
<b>B</b>	23	17	13	<b>53</b>	12	9	9	<b>30</b>	14	33	18	<b>65</b>
<b>C</b>	4	11	12	<b>27</b>	3	4	7	<b>14</b>	3	6	7	<b>16</b>
<b>D</b>	0	2	1	<b>3</b>	3	3	4	<b>10</b>	0	0	2	<b>2</b>
<b>E</b>	1	0	1	<b>2</b>	2	0	0	<b>2</b>	1	1	1	<b>3</b>

**Key for Table 4.27**

A - Always      B - Often      C - Sometimes      D - Rarely      E - Never

Grade 10 to Grade 12 students followed the same pattern as the lower grades in their replies with the majority of students again replying 'Always' and 'Often'. No significant difference in responses given by students of different grades or gender was noticed, though it has to be said that out of the three sciences, Chemistry, seemed to have a higher percentage of students who had trouble understanding the aims and what went on during an experiment, with Physics students faring best.

The next set of questions asked the students what mode of instructions was used, whether they understood them and how they could be improved. Students were allowed to choose more than one option. Figure 4.17 displays the types of instructions given to students across all grades by subject:

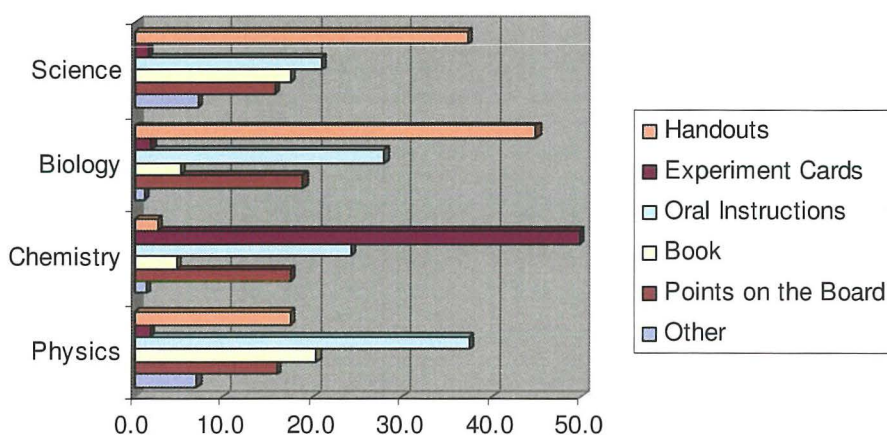


Figure 4.17: Percentage distribution of types of instructions given to students by Subject

When all subjects were taken together it was noted that Science (37.2%) and Biology (44.9%) instructions are given mostly as handouts<sup>1</sup>, Chemistry instructions are predominantly given as ‘Experiment Cards’<sup>2</sup> (49.7%) and Physics instructions are primarily given orally (37.4%). While, as mentioned, most Chemistry instructions are given as ‘Experiment Cards’, this method is the least used in all the other subjects. With regards to ‘Other’, Grade 8, 9 and Physics students said that they receive a workbook with instructions while those in Biology and Chemistry said that the teacher gives them instructions while doing the experiment. The General Science teacher also said that students are given a booklet with instructions. Therefore, it seems that teachers use various techniques to give instructions, some of which are pre-planned, like handouts, while others are given during the course of the lesson without prior formal planning, like when clarifying instructions using the whiteboard. We should also keep in mind that the school caters for students of different abilities and so it may be the intention of the teachers to use various methods to target all students.

One Physics teacher said that *“We give them a handout and the instructions ... they have to follow the instructions so that they’re not totally lost, we try and give them the instructions on what to follow step by step”*. While the other said that she always explains the goal of the experiment first.

The Chemistry teacher said that *“the instructions will actually tell the students what they have to do in order to reach the aims of the practical.”*

The Biology teacher gives instructions *“based on what the students require and that the students obtain from the practical session plus any added information, any added skills that the teacher decides that the students should have at the end of the session.”*

With a seemingly large variety of instructions provided, students were asked whether they understood the instructions given. The results are summarised in Tables 4.28 and 4.29.

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<sup>1</sup> A handout is a sheet which would have both the instructions for carrying out the experiment and also instructions for writing the report.

<sup>2</sup> An Experiment Card is an instruction sheet given to the students during the experiment. The procedure the students are to follow would be written on it.

Table 4.28: Do you understand the instructions given? (Science Students)

	Grade 8 (n = 82)			Grade 9 (n = 75)			Science Totals (n = 157)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
<b>A</b>	19	10	<b>29</b>	12	8	<b>20</b>	31	18	<b>49</b>
<b>B</b>	19	19	<b>38</b>	18	16	<b>34</b>	37	35	<b>72</b>
<b>C</b>	7	8	<b>15</b>	12	3	<b>15</b>	19	11	<b>30</b>
<b>D</b>	0	0	<b>0</b>	1	2	<b>3</b>	1	2	<b>3</b>
<b>E</b>	0	0	<b>0</b>	3	0	<b>3</b>	3	0	<b>3</b>

**Key for Table 4.28**

A - Always      B - Often      C - Sometimes      D - Rarely      E - Never

Table 4.29: Do you understand the instructions given? (Grades 10-12)

	Biology (n=135)				Chemistry (n=83)				Physics (n=158)			
	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total
<b>A</b>	22	15	15	<b>52</b>	9	10	8	<b>27</b>	21	20	17	<b>58</b>
<b>B</b>	18	19	21	<b>58</b>	12	11	13	<b>36</b>	18	34	23	<b>75</b>
<b>C</b>	3	9	10	<b>22</b>	3	3	4	<b>10</b>	7	7	8	<b>22</b>
<b>D</b>	0	1	0	<b>1</b>	4	2	1	<b>7</b>	0	1	1	<b>2</b>
<b>E</b>	1	0	1	<b>2</b>	2	1	0	<b>3</b>	1	0	0	<b>1</b>

**Key for Table 4.29**

A - Always      B - Often      C - Sometimes      D - Rarely      E - Never

Here as in the previous questions the students again mostly responded ‘Always’ or ‘Often’, with very few saying ‘Rarely’ or ‘Never’. These results, coupled with the ones for aim and what goes on during an experiment, seem to indicate that students usually have no problem understanding all aspects of the experiment irrespective of grade or gender or type of instructions given. Therefore one can assume that using their various techniques teachers were able to explain what has to be done to the vast majority of their students.

#### 4.11.1 Suggestions for Improvement of Instructions

Finally students were asked what could be done to improve the experiments. A large portion of the students did not have anything to add. As one Grade 9 boy said, “*Nothing, it’s already understood and crystal clear.*” This is in line with what is written above where most students said that they ‘Always’ or ‘Often’ understood the instructions given.

Those that offered suggestions mentioned how the teacher could improve his/her instructions to be understood better. Most students irrespective of subject, grade or gender suggested that they would understand better if the teacher explained better. Some suggested that this can be achieved by speaking more slowly, giving more detail, writing instructions on the board or by doing demonstrations.

The Grade 8 students suggested having the steps clearly written down and adding pictures next to the steps in handouts. A number of Chemistry and Physics students also suggested that drawing diagrams on the board or on handouts would be helpful in understanding instructions better. Some Grade 12 Physics students also suggested that having “*less rushed explanations would reduce misunderstandings*” (Grade 12 Physics, girl).

## 4.12 Types of Practical Work done

### 4.12.1 Inductive or Deductive Experiments

Halliday and Martin (1993) divide experiments into two types; the inductive in which the experiment is used to make observations for which a theory needs to be constructed by the way of explanations, and the deductive; in which the experiment is used to illustrate existing theories. Tables 4.30 and 4.31 show the results obtained when students were asked which order they thought helped them learn better, covering theory and then doing the experiment or vice versa.

**Table 4.30: Which order do you think would allow you to learn better, covering theory and then doing the experiment or vice versa? (Science Students)**

	Grade 8 ( $n = 82$ )			Grade 9 ( $n = 73$ )			Science Totals ( $n = 155$ )		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
<b>A</b>	33	31	<b>64</b>	22	20	<b>42</b>	55	51	<b>106</b>
<b>B</b>	12	6	<b>18</b>	23	8	<b>31</b>	35	14	<b>49</b>

**Key for Table 4.30**

A - Theory then Experiment

B - Experiment then Theory



*“Students tend to find the practical work a little bit intimidating and most of the time unless you actually go there and explain the results they don’t even realise what they’re actually proving. So if you set out on an investigation without first explaining it to them, most probably will get little from the experiment.”*

All the teachers, though, mentioned that the order chosen depends on the topic being taught. One Physics teacher summed it up saying:

*“It depends, there are certain applications, certain concepts, where first you have to do the theory and then they do the experiment so they can connect, whilst for other concepts it’s good to do the experiment and they try to get out the concept themselves.”*

This was backed up by the General Science teacher who said that *“it depends on the topic”*. The Chemistry teacher concurred saying that in certain experiments the reaction obtained made it easy to teach the concept to the students whereas in others, if you did not explain beforehand, they would have trouble grasping the aim of the experiment. The Biology teacher said:

*“I’d say a mixture of both because there are topics that are better understood during the practical part and then there are topics that can be done with the theory first and the practical after in which case the practical would be used to prove the theory.”*

The teachers’ comments differed from those of Xuereb (1996) in which he found that few teachers use experiments through which theory is learned because it is very time consuming.

#### **4.12.2 Experiments Students Prefer**

Asking students which experiments they preferred gave a good indication of what aspects they like about practicals. When students were asked to name the experiment they remember the most, a variety of answers were given. The Grade 8 students remembered ‘The Plug’, ‘Circuits’ and ‘Making Crystals’ the most:

*“I remember it the most because we could keep the crystals and I still have it in my locker.”*

(Grade 8, girl)

The majority of Grade 9 students said that ‘Making bread’ was the experiment they remembered most followed by the ‘Food tests’ and ‘Respiration in Yeast’.

Irrespective of the experiment, the Grade 8 and the Grade 9 students said that they remembered the particular experiment the most because it was fun (30.5% and 42.1% respectively). The Grade 8 students also said that they remembered particular experiments because they were easy (15.9%). Students also remembered experiments which they found interesting (12.2% Grade 8 and 11.8% Grade 9 students):

*“I had the most fun because then we got to try the bread which we baked.”*  
(Grade 9, boy)

*“It was interesting and I didn't have an idea which food had what in them so it was a surprise.”*  
(Grade 9, girl)

The Grade 8 students also mentioned that they learnt something from the experiment they remembered the most, while some of the Grade 9 students who chose ‘Making Bread’ remembered it because they got to eat the bread. Students seemed to remember the experiments which related to their lives and which they thought could be helpful in the future:

*“I remember it because my father sells them.”*  
(Grade 8, boy)

*“It was fun and it would be helpful in the future.”*  
(Grade 8, girl)

Other students seemed to be impressed with the unusual and the unexpected:

*“Because it was something that impressed me and because I've never seen it before.”*  
(Grade 8, boy)

*“This is because of the colours and I was amazed that all 7 colours make white.”*  
(Grade 9 girl, with reference to Newton’s disc)

The ‘Osmosis’ experiment was the one remembered the most by Grade 10 Biology students closely followed by the experiments of ‘Photosynthesis’ and ‘Diffusion’. The Grade 11 Biology students remembered the ‘Dissection’ most, followed by the

'Respiration' and then the 'Food tests'. The 'Dissection' proved to be the most popular with the Grade 12 students as well, followed by the 'Food Tests' and the 'Fitness tests'.

For Chemistry the Grade 10 students had a tie between 'Separating Techniques' and 'Burning Substances' followed by 'Heating Salts'. In Grade 11 most students remembered 'Group 1 metals in water' followed by 'Volumetric Analysis' and 'Electrolysis' while in Grade 12 most students remembered 'Making Esters' followed by a tie between 'Group 1 metals in water' and the 'Flame Tests'.

For Physics most Grade 10 students remembered 'The can experiment' and the experiment of 'Water Pressure'. The 'Pendulum' was the next most popular. Most of the Grade 11 students remembered the 'Van der Graff generator', followed by the experiment of 'Gravity' and the 'Laws of Motion'. An overwhelming majority of Grade 12 students remembered the 'Specific Heat Capacity' the most, followed by 'Waves in the ripple Tank'. 'Volume' and 'Stroboscope' were tied for third most popular.

Like their younger counterparts a sizable portion of the older students said that they remembered a particular experiment because it was fun (the exception being the Grade 12 Physics students where no one mentioned this). Working with friends during some experiments also made them memorable:

*"This practical was fun as we got to do it with our friends."*

(Grade 10 Biology, girl)

Some students (mainly Biology students) said that they remembered an experiment because they found it interesting. Others mentioned that the most memorable experiment was a long experiment. A Grade 10 Biology girl also mentioned that "*it helped me understand what I didn't in the theory*". Students irrespective of subject seemed to remember an experiment more if they were impressed by it visually or if it affected another one of their senses like smell:

*"We actually had real bull organs ... not easy to forget the blood."*

(Grade 12 Biology, girl)

*"A very pleasing relaxing smell."*

(Grade 12 Chemistry, boy talking about esters)

*“It was real fun watching the metal’s violent reactions.”*

(Grade 11 Chemistry, boy)

*“It was the most fun and there were loads of different effects and changes.”*

(Grade 10 Chemistry, girl)

*“The flying water was fascinating”* said a Grade 10 Physics boy who remembered water pressure the most and *“we got wet and learned more”* (Grade 10 Physics, girl).

Students remembered an experiment more if it involved something unusual or had something they enjoyed. With reference to staining onion cells *“it was fun and interesting to see the onion cell up close. Plus I enjoy drawing diagrams of cells”* (Grade 10 Biology, girl).

*“Because it involved a lot of delicate apparatus so it required a lot of concentration.”*

(Grade 11 Chemistry girl, on volumetric analysis)

*“Because we went outside and did something different than staying in the lab.”*

(Grade 10 Physics, girl)

#### **4.12.3 Different Types of Practical Work carried out in the School Laboratory**

Wellington (2002) believes that there are at least six types of activities which are likely to be classified as practicals: teacher demonstrations; class practicals, with all learners on similar tasks, working in small groups; a circus of ‘experiments’, with small groups engaged in different activities, rotating in a ‘carousel’; investigations, organised in one of the above two ways; and problem-solving activities.

Teachers were asked about four types of practicals; experiments that teach skills, demonstrations, experiments that illustrate phenomena and investigations. All teachers, irrespective of subject taught, said that they carry out experiments that teach skills.

*“To separate them (different mixtures) you have to use glassware so that would be the very first practical of the course so they would be introduced to some basic equipment like the Bunsen, like flasks, like funnels and beakers, setting up a basic water bath and they would be required to know how to handle these, I mean, one of the objectives of the practical is actually to acquaint the students with the use of this basic equipment.”*

(Chemistry teacher)

*“Apart from proving Ohm’s law, voltage is proportional to current, they spend the first 15 minutes of the practical assembling circuits and obviously I go round to check circuits where I point out ‘listen, the circuit is not well connected look at the diagram and try to replicate the diagram in the actual circuit’.”*

(Physics teacher)

By the end of such an experiment, students should *learn* “*how the equipment is used and what it is used for*”. The skill is not normally the focus of the experiment but part of it. That is, in order to perform the experiment students would have to learn the skills involved:

*“It would be part of an experiment, for example, in Hooke’s law the basic skill is how to read a meter ruler at eye level.”*

(Physics teacher)

Some other skills are not tested for the simple reason that they are not safe to be handled by students:

*“I’m not going to test electromagnetism with students because over there we are using large currents so I end up setting up the apparatus for them beforehand.”*

(Physics teacher)

Experiments which involve skills are done because “*it’s easier to actually show the kids, ‘listen, this is how it’s done’ rather than spending a whole day speaking about them*” (Chemistry teacher).

Demonstrations are carried out by all science teachers where usually they are “*small aspects of the lesson which require a visual approach*” (Biology teacher). The Chemistry teacher gave dehydration properties of concentrated sulphuric acid as an example. They are carried out “*when there is not enough apparatus for the students to do it*” (Physics teacher) or “*there won’t be time to do each and every experiment as a report*” (Physics teacher). The Chemistry teacher noted that sometimes:

*“The reaction would be too dangerous, it releases something which is toxic and if carried out as a practical it can actually be harmful or because the equipment involved is too expensive and we just have one or two sets of it or because of the fact that the reactions will be too simplistic.”*

In General Science demonstrations usually take place if *“the experiment is dangerous, I demonstrate first, then the students”*. Biology demonstrations are sometimes carried out for experiments that *“would normally take a very long time to complete so the experiment is actually prepared beforehand and the students get to observe the results”*.

Experiments that illustrate phenomena are also carried out by all science teachers. They are used for *“giving proof of something that seems incredible or fantastic”* (Physics teacher). This is described by the General Science teacher as:

*“Though they see it in nature, they understand what’s really happening”*  
(when talking about the experiment of the refraction of white light)

In Chemistry they are used:

*“To reinforce the pathway taken by the reactants to form the products ... although they would be covered from a theoretical point of view, having it being carried out is something which is more concrete ... in general then you have to test for what you produce and that is helping them to apply the knowledge.”*

Investigations are also done in all grades and subjects where, according to the Biology teacher, they teach

*“students what to look out for when they are studying or revising. Basically understanding how a topic came to be known gives skills to students, observation skills with students which make it easier for them to memorise certain kind of topics.”*

The Chemistry teacher sees investigations as an opportunity to *“take what is learnt in class and apply it to an unfamiliar situation”*.

In investigations,

*“the students are provided with a problem, a specific problem and they have to, through the knowledge obtained during lessons in class, establish a methodology that is suitable for comparing these parameters and compare them in a fair way, carry out the experiment and then compare the results to see if there is a discrepancy and if there is, why there is a discrepancy.”*

(Biology teacher)

In the case of Physics “students find investigations extremely hard because the investigation requires mathematics”. The General Science teacher also sees it as an opportunity to do research and look up on the Internet.

When asked which of the four types of practicals is the most important I received mixed answers. While the General Science, Biology and Chemistry teachers said they were all important with the Chemistry teacher saying that “there should be a variety of these kinds of investigations, you can’t say one is more important than the other, each have their own value, they have to accompany the subject and they have to be used in the subject depending on the situations arising”, the Physics teachers on the other hand had differing opinions, one saying that the investigative experiment were the most important and the other saying that the illustration experiments were the most important.

#### 4.12.4 Do Students Design Experiments?

It has been suggested that:

*“when properly developed, inquiry-centred laboratories have the potential to enhance students’ meaningful learning, conceptual understanding, and their understanding of the nature of science.”*

(Hofstein, et al., 2004, p.47)

With this in mind I asked the students whether they had the opportunity to design experiments themselves as can be seen in Tables 4.32 and 4.33.

**Table 4.32: Do you ever have experiments where you design the experiment yourself without the help of instructions? (Science Students)**

	Grade 8 (n = 81)			Grade 9 (n = 73)			Science Totals (n = 154)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
<b>A</b>	15	3	<b>18</b>	4	0	<b>4</b>	19	3	<b>22</b>
<b>B</b>	30	33	<b>63</b>	40	29	<b>69</b>	70	62	<b>132</b>

**Key for Table 4.32**

A - Yes

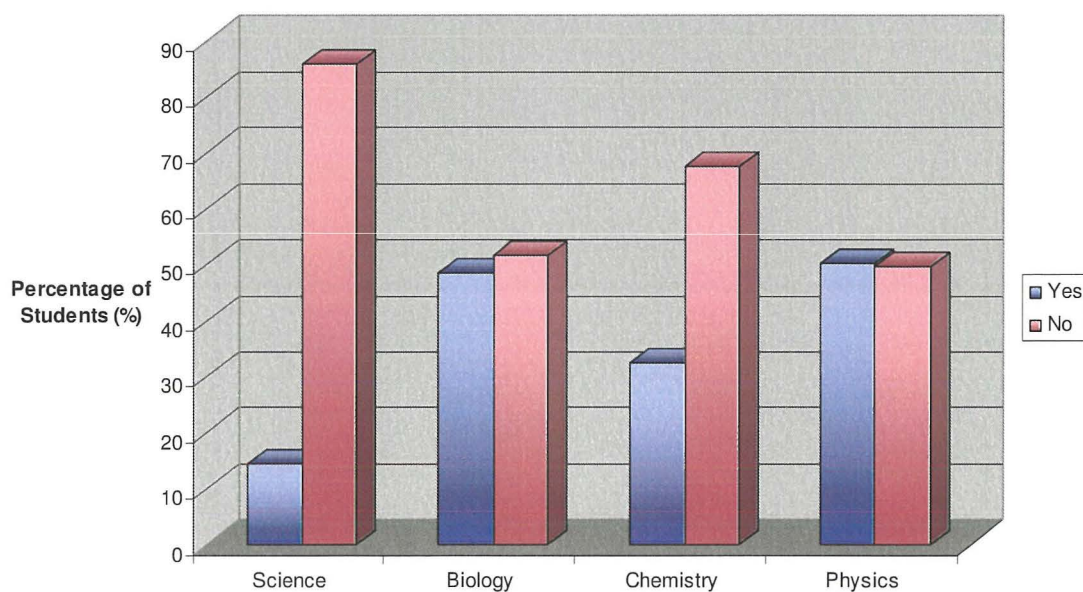
B - No

**Table 4.33: Do you ever have experiments where you design the experiment yourself without the help of instructions? (Grades 10-12)**

	Biology ( <i>n</i> =136)				Chemistry ( <i>n</i> =83)				Physics ( <i>n</i> =159)			
	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total
<b>A</b>	23	24	19	<b>66</b>	10	15	2	<b>27</b>	18	27	35	<b>80</b>
<b>B</b>	22	20	28	<b>70</b>	20	12	24	<b>56</b>	29	36	14	<b>79</b>

**Key for Table 4.33**  
**A** - Yes      **B** - No

When asked whether they ever designed the experiments themselves a marked difference was noticed between the Science students and the students in higher grades. While there was not a majority of students in any grade which replied 'Yes', the percentage saying 'Yes' in the lower grades was very low (22.2% and 5.5%) increasing to 41.8%, 49.3% and 45.9% in Grades 10, 11 and 12. This seems to imply that from year to year students are encouraged to come up with the design of the experiment more frequently. This however was not true for all the science subjects where 48.5% of Biology students and 50.3% of Physics students replied 'Yes' while only 32.5% of Chemistry students gave the same answer. The difference in responses (Figure 4.18) may be due to some students not seeing a difference between traditional practicals and designing an experiment.

**Figure 4.18: Percentage of students who had to design some of the experiments themselves by Subject**

When asked how designing the experiment can affect the learning of the subject, one of the Physics teachers replied as follows:

*“That is very important, it is something done in Grades 11 and 12. Apart from there being an actual question in MATSEC where you have to design an experiment, I think over there we’ll be testing the analytical skill of a student and it’s over there where we can really judge whether this is a student who’ll perform really well in the subject or not. I believe in it very much and I think it’s the ultimate way on how you can test a student in experimental physics.”*

The Chemistry teacher said that having the students taking on the whole experiment in their hands helped promote active thinking and, besides increasing their attention span during the experiment, helped them remember the concepts learnt more. However he said that this was not always practical seeing that it was much more time consuming than passive learning. When asked whether students were ever asked to pose the question to be investigated, formulate a hypothesis to test or plan the experimental procedure, he replied as follows:

*“Well, formally no, however when there are investigative experiments, what I usually do is that I present them in a puzzle fashion and then they have to devise it, and although it would already have been a pre-planned idea, I present it to the kids as if it wasn’t. A case in point is when we do energetics and I present them with the idea that they have to devise a piece of gadgetry that is actually going to measure heat of combustion. Now obviously I would have in mind the Bomb Calorimeter and it would be ready in the box to be opened and shown to the kids, but I present it as if they have to devise the thing and then they themselves actually come up with the difficulties and discuss the weak points of what they would devise. I do something similar when it comes to how to collect gases in chemistry and ask them how it can be done. Again, I would have a set of five preconceived ideas in my mind but they have to come up with them. So they are presented as if they would have to plan them out but I would have a preconceived idea of the thing.”*

#### **4.12.5 The Experiments Students Prefer**

Students were then asked which type of practical they would prefer, the results of which are shown in Tables 4.34 and 4.35.

Table 4.34: Which type of practical work would you prefer? (Science Students)

	Grade 8 (n = 89)			Grade 9 (n = 82)			Science Totals (n = 171)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
<b>A</b>	25	19	<b>44</b>	21	13	<b>34</b>	46	32	<b>78</b>
<b>B</b>	13	8	<b>21</b>	15	16	<b>31</b>	28	24	<b>52</b>
<b>C</b>	13	11	<b>24</b>	12	3	<b>15</b>	25	14	<b>39</b>
<b>O</b>	0	0	<b>0</b>	2	0	<b>2</b>	2	0	<b>2</b>

**Key for Table 4.34**

- A - Designing your own experiment
- B - Following a given set of instructions
- C - Teacher demonstrations
- O - Other

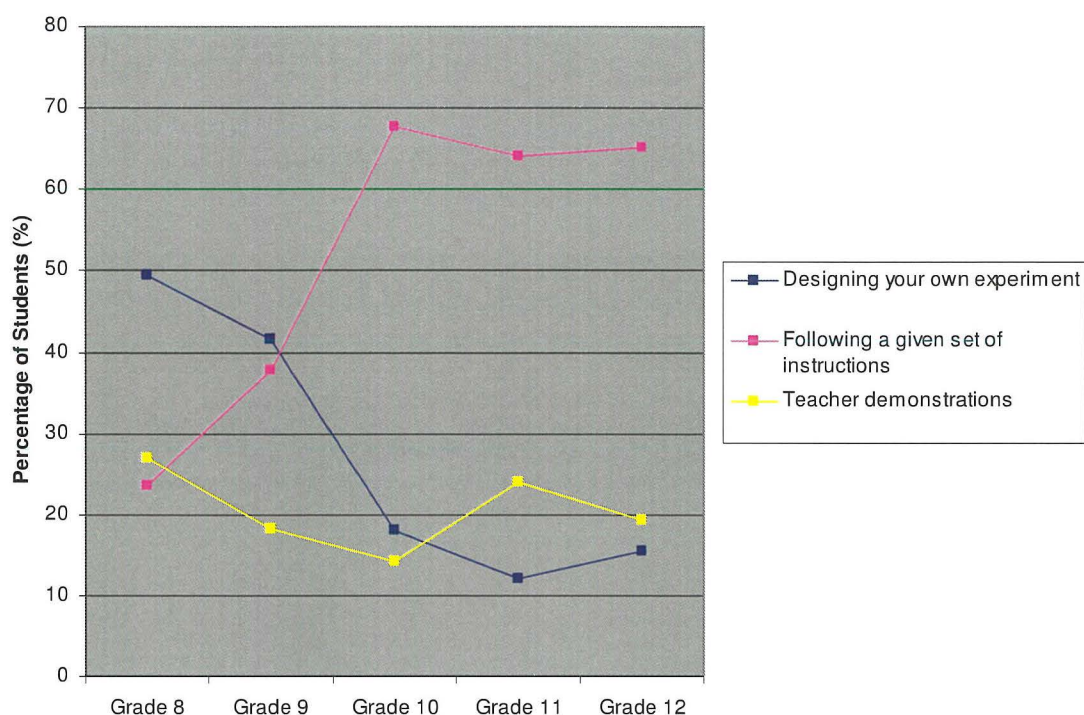
Table 4.35: Which type of practical work would you prefer? (Grades 10-12)

	Biology (n=146)				Chemistry (n=86)				Physics (n=180)			
	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total
<b>A</b>	7	5	8	<b>20</b>	4	4	3	<b>11</b>	13	9	9	<b>31</b>
<b>B</b>	35	37	33	<b>105</b>	22	15	20	<b>57</b>	33	44	31	<b>108</b>
<b>C</b>	6	6	9	<b>21</b>	5	10	3	<b>18</b>	8	20	13	<b>41</b>
<b>O</b>	0	0	0	<b>0</b>	0	0	0	<b>0</b>	0	0	0	<b>0</b>

**Key for Table 4.35**

- A - Designing your own experiment
- B - Following a given set of instructions
- C - Teacher demonstrations
- O - Other

A marked contrast was noticed between the Science Students (Grades 8 and 9) and the students in higher grades (as can be seen in Figure 4.19). While 'Designing your own experiment' was a very popular choice with Science students (49.4% in Grade 8 and 41.5% in Grade 9), its popularity plummeted from Grade 10 onwards (18%, 12% and 15.5%) whereas 'Following a given set of instructions' which was only moderately popular with Science students (23.6% and 37.8%), shot up to most popular in all subsequent grades with 67.7%, 64% and 65.1% in Grades 10, 11 and 12 respectively. Teacher demonstrations were generally mildly popular throughout (20.6% average). All three Science subject students (Grades 10-12) followed the same pattern of choice with 'Following a given set of instructions' being the most popular and 'Designing your own experiment' the least. No big difference of opinion based on gender was noticed, unlike the study carried out by Stark and Gray (1999) in which they found that girls preferred teacher demonstrations.



**Figure 4.19: Which type of practical work would students prefer by Grade**

When comparing the results obtained with those of the previous question, where students were asked if they ever designed experiments themselves, it was noted that those students who rarely got to design their own experiments (Grades 8 and 9) wanted the opportunity to do more, while those who did design their own experiments wanted less. This seems to imply that either designing an experiment is not presented to students in an attractive form, or that as students become older they do not want to ‘make mistakes’ possibly because the content becomes more difficult and because they start to realise their importance for the SEC-level examination. It might also indicate that as students grow older they become less keen to try something out or they just become lazier. It might also be as Fullick (2005) points out that students are usually aware of their own shortcomings and of the shortcomings of the school’s apparatus and therefore are less confident designing an experiment themselves. In fact, in research done by Stark and Gray (1999) and Pell and Jarvis (2001), similar results were found, with 10/11-year-old students having positive attitudes to science as a whole and a preference for independent investigations and 13/14-year-olds being less motivated and more likely to fail to complete questions which looked unfamiliar or challenging.

While the preferences seemed to vary between the Science students and the students in higher grades, the reasons given for preferring each type of experiment were similar throughout. Those students who preferred designing their own experiments mentioned the

experiment being more fun as the main factor, closely followed by the feeling that designing your own experiment gives you a greater sense of accomplishment and making it easier to remember. One Grade 8 boy said that *"I would prefer this once in a while so we would have a challenge to design something ourselves"* while another said it *"leaves more fun work into our hands and proves us trustworthy"*. The higher grade students concurred with a Grade 11 girl (Biology student) saying that *"you remember what is happening better than if you are following a set of written instructions and much better than demonstrations"* and a Grade 12 girl (Biology student) saying *"it helps you understand and prove to yourself that you are understanding the topic."*

The overriding reason given by those students who prefer following instructions was that it minimised mistakes and was easier to do. A number of Grade 8 students said that *"nothing would go wrong"* by following instructions and a Grade 8 girl mentioned that *"it is better because we just follow and we cannot make a mistake"*. A Grade 9 boy said that following instructions was better as opposed to designing the experiment yourself *"because if you do something wrong you will remember it wrong"*. A considerable number of Grade 10 to 12 students again mentioned the feeling that following a set of instructions made the experiment much easier and minimised mistakes with one Grade 10 boy (Biology student) saying that he preferred *"getting it right first time"*. A Grade 12 Chemistry student (boy) also mentioned that *"it would be dangerous"* to perform the experiments without following instructions, with a fellow student saying he would not trust himself to design a practical. One Grade 12 Physics student (girl) summed it all up by saying *"it is the easiest way and the quickest"*. Attard (2006) also found that students felt confident carrying out recipe-type experiments.

Morrow (1999) investigated Biology students' attitudes to designing their own experiments. Fifty-three per cent of the students preferred designing an experiment to following a set of instructions as they reported understanding the purpose of the experiment better, learning more, having more freedom and control in planning the experiments. Students had to think more and the experience was described as 'challenging', 'fun' and like 'realistic science'. Moreover, students felt that by designing their experiments they understood the content better than when they followed instructions. On the other hand, those students who preferred a set of instructions stated it was easier and more convenient, and there was less room for error. They also seemed to feel more at

ease with the thought that their answers would be more or less the same as the rest of the class.

Similarly, Nott and Wellington (1999) found that though most students preferred investigative practicals, a sizable group reported that they preferred more traditional practicals since they knew where they were and if they were doing it right.

Better understanding was the main point given by those students who would prefer teacher demonstrations. A Grade 8 girl said that with the teacher doing the experiment *“every single person would understand the way he/she should work it out”*. A fellow Grade 8 student (boy) also mentioned that *“it would be safer”*. A Grade 11 Biology student (girl) said that demonstrations were easier to understand *“because the teacher can explain while demonstrating”*. One Grade 12 Physics student (girl) also mentioned the time factor saying *“sometimes you would need to just watch because it’s useless to take a double lesson to carry out a simple experiment”*. Chemistry students seemed particularly wary of the perceived danger of their experiments with a Grade 11 boy saying *“if something wrong happens it would be the teacher’s fault”* and another (Grade 12) saying that *“chemical substances can be very dangerous”*. It seems that lack of confidence is found in both males and females and especially so in those studying Chemistry (though this might be due to the Chemistry experiments being perceived as more difficult and dangerous).

#### **4.13 Grouping during Practical Work**

In a study carried out by Frost et al. (2005), 90% of post-16 students said that group work and collaboration exercises made science more interesting while 55% of 11–14-year-olds gave positive responses. On similar lines, two questions were aimed at determining whether the students preferred working individually, in pairs or in groups and the reasons why (Tables 4.36 and 4.37). The teachers were also asked for their view on the subject.

Table 4.36: Should the practical work be carried out individually, in pairs or in groups? (Science Students)

	Grade 8 ( <i>n</i> = 87)			Grade 9 ( <i>n</i> = 78)			Science Totals ( <i>n</i> = 165)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
A	6	5	11	8	2	10	14	7	21
B	22	25	47	24	19	43	46	44	90
C	19	10	29	16	9	25	35	19	54

**Key for Table 4.36**  
A – Individually                      B – Pairs                      C – Groups

Table 4.37: Should the practical work be carried out individually, in pairs or in groups? (Grades 10-12)

	Biology ( <i>n</i> =138)				Chemistry ( <i>n</i> =82)				Physics ( <i>n</i> =164)			
	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total
A	4	4	5	13	0	5	2	7	4	11	5	20
B	18	23	27	68	13	11	17	41	26	27	22	75
C	23	18	16	57	17	11	6	34	20	27	22	69

**Key for Table 4.37**  
A – Individually                      B – Pairs                      C – Groups

Working in pairs was the preferred method across all subjects while working individually was the least preferred. The results were the same when considering different grades, the only exception being Grade 10 where working in groups was slightly more popular than working in pairs (48% against 45.6%). Working individually was particularly unpopular, with the largest percentage of students choosing it being 14.6% in Grade 11. It was particularly disliked by Grade 10 students (6.4%) and Chemistry students (8.5%) with no Grade 10 Chemistry student preferring it. As for gender, girls tended to prefer working in pairs more than boys (the only exception being again Grade 10), while the majority of the students who preferred to work individually were boys. Working in groups was liked similarly by both sexes.

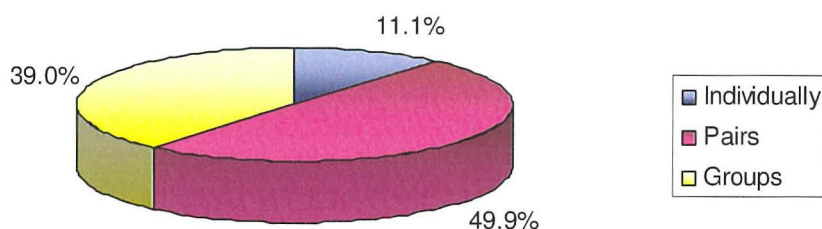


Figure 4.20: Preferred method of carrying out experiments (All Students)

Some students said they would prefer to do practicals individually because in that way “everyone gets to do everything” (Grade 8 girl) and “You won't learn if someone else does it” (Grade 8 boy). Some students said that working alone prevents them getting distracted:

*“Because I can concentrate more on my own.”*

(Grade 11 Physics, girl)

Several Grade 9 students said “I am a loner” (Grade 9 boy) and said that they did not like sharing materials and apparatus “so that you don't have to stay saying you do this and I do that” (Grade 9, boy).

One Biology student said that working individually is better for some experiments as it is “easier when looking at the microscope” (Grade 10 Biology girl) while another mentioned that it would be better “so that the teacher can assess the students individually. In groups two people could do everything while another person does nothing” (Grade 11 Chemistry, boy).

Students who said that experiments should be carried out in pairs, considered groups to be too big and cramped but at the same time did not like working individually because they could get stuck without having anyone to help them:

*“Because it will sometimes be hard to do it on your own and in groups it will be too crowded.”*

(Grade 8, boy)

*“It is best because if you get stuck and the teacher is busy there's your partner to help you out, and it's not too many people so it is not chaotic.”*

(Grade 10 Physics, girl)

Pairs are also considered ideal “because you have a second opinion” (Grade 12 Biology, girl). Some believe that experiments “should be done in pairs as we will work efficiently” (Grade 10 Biology, boy) and it “encourages teamwork but doesn't have the confusion of a large group” (Grade 12 Chemistry, boy).

Pairs were described as being more fun as “you can learn new things with your friends” (Grade 9 boy) while “if there are a lot of people apparatus can break easily” (Grade 9, girl) and that it can be “too dangerous to work in groups (sometimes)” (Grade 11 Biology, girl).

Some of the students who prefer working in groups said that they prefer to do so as there will be more people to help them out if they get stuck and *“it will be more fun”* (Grade 11 Physics, boy).

*“I prefer them in groups because you will be a lot of people and if you don't understand they can help.”*

(Grade 8, girl)

Groups also provide the opportunity for more discussion and provide more people to solve problems.

*“A group of brains is better than one!!!”*

(Grade 12 Physics, boy)

Groups were preferred by some as they could *“learn how to socialise”* (Grade 10 Biology, girl) and *“could learn to work in a group”* (Grade 11 Biology, boy).

Groups were also considered *“to take up less time”* (Grade 11 Biology, girl) *“because we can separate jobs and get the practical done on time”* (Grade 11 Chemistry, girl).

In their study Chin and Kayalvizhi (2005) found that most students preferred to work in groups because it is better for generating ideas and discussions, friends help out when problems arise and investigations are carried out more quickly. However, the students also noted problems with groups such as disagreement over ideas related to the investigations, some members being left out while others monopolising activities, some members not contributing or bringing the required materials, off-task behaviour and communication problems.

When asked whether practicals were carried out individually, in pairs or in groups, both the General Science and the Chemistry teacher replied that they were mostly done in groups, in the case of Chemistry citing time as the main reason. However he did stress that although the practicals were done in groups *“... I would make sure that each and every member in the group has a go at trying to reinforce the skills I want them to reinforce”*. The Physics teachers stated too that most of the practicals were carried out in groups with some being done in pairs. The main reason given was the apparatus or lack thereof, with not enough apparatus being available to carry out particular experiments individually. However they also mentioned that they would rather have the students working in groups

to help each other out than individually whether the apparatus was available or not. The Biology teacher was the only one to say that some of the experiments were carried out individually though most were done in pairs or in groups of three. He mentioned that individual experiments were carried out mostly where *“an observation from a microscope has to be put down on paper.”* As for working in pairs or in groups, time was again the factor mentioned, with the teacher saying *“where there is a lot of work to be done in a single session we prefer group work so that the work can be split over different people.”*

Students are however encouraged to pool results. This is done *“because like that we have the average which will get a more reliable result”* (Physics teacher) and also when the students carry out surveys.

When asked whether informal discussions were allowed during laboratory work, the teachers gave differing answers. The Physics teacher said that they were not allowed, stating that due to the amount of work to be done in a short time, she kept them busy throughout the session. While she said that there was not perfect silence during an experiment she did not formally allow discussions. The Chemistry teacher also said that he did not allow discussions during an experiment however he allowed and even encouraged them after, when discussing results, to allow the students to come up with a conclusion together. The main reason given for not allowing discussions during an experiment was safety which became a non-issue once the experiment was over. The Biology teacher on the other hand allows informal discussions throughout the session provided they do not disrupt the class. Likewise, the General Science teacher allows informal discussions as she sees them as an opportunity for student - teacher interaction; *“because sometimes they have certain ideas which are not correct and can be corrected”* and the teacher will know what information the students hold.

Finally when asked whether they thought that practicals had any social goals, all the teachers responded positively to the question, saying they found it to be an important factor. The main reason given by all teachers was that when the students were working in groups they had to collaborate with each other to obtain a successful result. They also mentioned that they helped to create new friendships when students were paired with colleagues they do not normally spend time with, with the Physics teacher making it a point to pair off the students herself. The Chemistry teacher also mentioned that in the

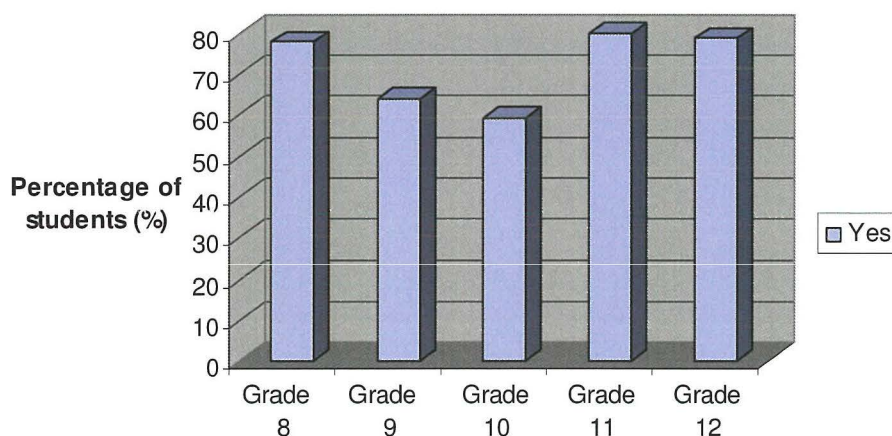
same way in which two specialist scientists help each other in a work environment, students learnt to use each others' strengths to complete a common goal.

#### 4.14 Students' Perceptions of Report Writing

The main function of a report is to organise information about things (Halliday and Martin, 1993). In addition the Britannica encyclopaedia explains that the main goal for a laboratory report should be to communicate clearly to the instructor what was done and observed in the experiment, as well as what the results mean. Therefore writing the report should help students understand the experiment better as they are given time to reflect on the work done.

##### 4.14.1 Report Writing: An Aid to Understanding the Experiment better

Students were asked whether report writing helps them understand the experiment better and it resulted that most students thought that report writing did help them understand the experiment better as evidenced in Figure 4.21.



**Figure 4.21: Percentage of students who thought report writing helped them understand the experiment better by Grade**

However, even though the response was positive across all grades, Grade 10 and, to a lesser extent, Grade 9 students' replies showed a drop in the number of students saying 'Yes'.

**Table 4.38: Does report writing help you understand the experiment better? (Science Students)**

	Grade 8 ( <i>n</i> = 81)			Grade 9 ( <i>n</i> = 75)			Science Totals ( <i>n</i> = 156)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
<b>A</b>	35	28	<b>63</b>	25	23	<b>48</b>	60	51	<b>111</b>
<b>B</b>	9	9	<b>18</b>	22	5	<b>27</b>	31	14	<b>45</b>

**Key for Table 4.38**

A - Yes      B - No

The drop from Grade 8 to Grade 9 (64% saying 'Yes' as opposed to 77.8%) seemed to be highly influenced by gender. While 79.5% of Grade 8 boys replied 'Yes', just over half (53.2%) of the Grade 9 boys gave the same answer. On the other hand, the percentage of female students saying 'Yes' increased slightly (up to 82.1% from 75.7%).

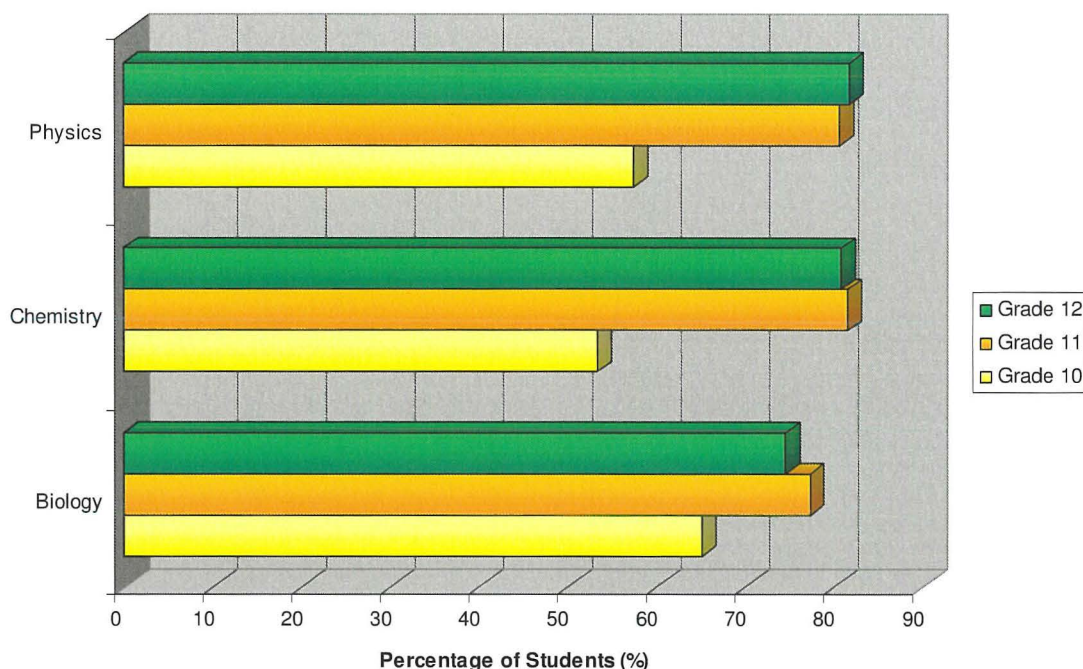
**Table 4.39: Does report writing help you understand the experiment better? (Grades 10-12)**

	Biology ( <i>n</i> = 134)				Chemistry ( <i>n</i> = 83)				Physics ( <i>n</i> = 158)			
	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total
<b>A</b>	28	34	35	<b>97</b>	16	22	21	<b>59</b>	27	50	40	<b>117</b>
<b>B</b>	15	10	12	<b>37</b>	14	5	5	<b>24</b>	20	12	9	<b>41</b>

**Key for Table 4.39**

A - Yes      B - No

Regarding the decrease observed in the positive responses in Grade 10 though, gender did not seem to play such a major part as both sexes contributed to the overall drop, and while the drop was spread across all three science subjects, the distinction between Grade 10 Chemistry and Physics students and their Grade 11 and 12 counterparts was more pronounced as seen in Figure 4.22. Chemistry students replying 'Yes' increased from 53.3% in Grade 10 to 81.5% and 80.8% in Grades 11 and 12 respectively. Similarly Physics students replying 'Yes' increased from 57.4% in Grade 10 to 80.6% and 81.6%. In Biology the distinction was slightly smaller with 65.1% replying 'Yes' in Grade 10 and 77.3% and 74.5% in Grades 11 and 12 respectively. This seems to imply that students in higher grades appreciate report writing as a help for understanding better.



**Figure 4.22: Percentage of Students who thought report writing helped them understand the experiment better (Grades 10-12)**

The science teachers seemed undecided about whether report writing helps students understand the practical better. The General Science teacher said “*no, writing the report does not help them understand the practical better but it helps them remember it more*”. The Physics teacher said that report writing helps “*some students link together practical work with theory, however the majority, the average to weak students, see absolutely no link, they fail to see this despite explaining as well as possible.*” The other Physics teacher mentioned that they help them understand the practical more. The Chemistry teacher noted that the writing of the report is intended to help students understand practicals better but “*whether or not they achieve the aim depends on the student’s performance, the student’s effort and the student’s understanding*”. The Biology teacher however mentioned that “*since the reports are done more or less in the same manner it tends to get the students to rely too much on the way the system is done and not be creative about the observations*”. The Chemistry teacher however describes report writing as helping students in a number of ways:

*“It helps their descriptive skills because they have to actually write about what they have observed; it probably improves their English skills knowing that the report is written in English. It also helps them to analyse better because they have realised so far that the whole aim of the experiment is to actually be able to explain the results and that usually is something which comes with practice and theory cannot explain it and I think that if the students learn that kind of thing it’s one of the main goals of practical work. Also the fact that accompanying the explanation comes an account stating the economic*

*importance of the practical or the substance studied in the practical is actually helping them realise that the subject is not something that should be confined within the four walls of the lab but should be taken outside and it relates to everyday life and that's the practical if we can achieve it."*

(Chemistry teacher)

#### 4.14.2 The Help given to write Reports

Students were then asked what sort of help they were given when writing reports. Where more than one type of help was given, students could tick multiple answers. Tables 4.40 and 4.41 show the results obtained.

**Table 4.40: What sort of help are you given to write a report? (Science Students)**

	Grade 8 (n = 144)			Grade 9 (n = 121)			Science Totals (n = 265)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
<b>A</b>	24	20	<b>44</b>	22	17	<b>39</b>	46	37	<b>83</b>
<b>B</b>	10	9	<b>19</b>	11	6	<b>17</b>	21	15	<b>36</b>
<b>C</b>	23	20	<b>43</b>	11	6	<b>17</b>	34	26	<b>60</b>
<b>D</b>	16	12	<b>28</b>	19	12	<b>31</b>	35	24	<b>59</b>
<b>E</b>	4	2	<b>6</b>	4	3	<b>7</b>	8	5	<b>13</b>
<b>F</b>	0	0	<b>0</b>	3	1	<b>4</b>	3	1	<b>4</b>
<b>O</b>	4	0	<b>4</b>	4	2	<b>6</b>	8	2	<b>10</b>

**Key for Table 4.40**

A - Handouts

B - Teacher dictates

C - Copying from board

D - Textbook

E - Work in a group

F - None

O - Other

**Table 4.41: What sort of help are you given to write a report? (Grades 10-12)**

	Biology (n=291)				Chemistry (n=152)				Physics (n=312)			
	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total
<b>A</b>	39	43	41	<b>123</b>	10	13	11	<b>34</b>	12	28	12	<b>52</b>
<b>B</b>	23	18	19	<b>60</b>	13	17	13	<b>43</b>	33	31	30	<b>94</b>
<b>C</b>	13	16	13	<b>42</b>	8	8	8	<b>24</b>	16	18	15	<b>49</b>
<b>D</b>	9	15	11	<b>35</b>	6	13	3	<b>22</b>	23	33	8	<b>64</b>
<b>E</b>	5	5	10	<b>20</b>	3	3	5	<b>11</b>	5	15	12	<b>32</b>
<b>F</b>	2	0	0	<b>2</b>	5	1	0	<b>6</b>	1	0	2	<b>3</b>
<b>O</b>	0	9	0	<b>9</b>	2	9	1	<b>12</b>	2	13	3	<b>18</b>

**Key for Table 4.41**

A - Handouts

B - Teacher dictates

C - Copying from board

D - Textbook

E - Work in a group

F - None

O - Other

‘Handouts’ were the most widely used type of help given to Science students (Grades 8 and 9) with ‘Copying from the board’ and ‘Textbooks’ coming second. ‘Teacher dictations’ were also given while ‘Working in a group’ was only used sporadically. ‘Handouts’ were also the most widely used type of help given to Biology students (42.3%). While ‘Handouts’ were also given to Chemistry and Physics students, ‘Teacher dictations’ were more prevalent in these subjects (coming second in Biology). ‘Textbooks’ remained a popular type of help especially with Physics students (20.4%) however it was rarely used in Chemistry experiments. ‘Copying from the board’ was used regularly by all three subjects. ‘Working in a group’ was again only used sporadically.

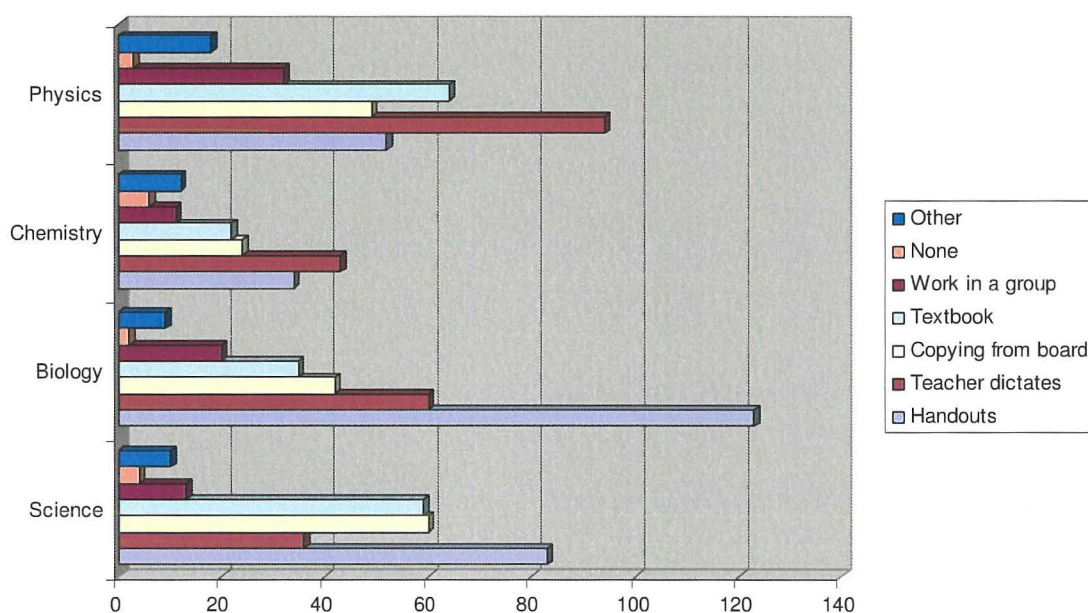


Figure 4.23: Type of help given to write reports by subject

The diversity of the responses suggests that the teachers use a variety of methods to help their students write the report better especially since most students ticked more than one option. This help may be given consciously in the form of handouts or informally in the form of an explanation on the board.

Teachers were asked about the sort of help given for writing the report and once again the responses were varied. A General Science teacher said that she gives them “an example of the report and they have to follow it ... the reports are written on the board then students can copy them”. The Physics teachers claimed that they only helped students with precautions and sources of error because these areas are given lots of importance by

MATSEC. Other than that they said that the students do the rest of the experiment report entirely on their own being given just a table to fill in:

*“With the Grade 10s we only help them with precautions and sources of error ... and they get to do the rest of the experiment absolutely on their own, not even a method is given to them.”*

(Physics teacher)

The other Physics teacher said, *“in the method I don’t give them help at all since they’re given a handout with the instructions. What I give them help in is results, I tell them ‘Look, your graph should look like this’”*. The Biology teacher varies the help given from year to year:

*“In Grade 10 they get report sheets or practical sheets where the instructions are all on the practical sheet and it is very easy to translate the practical sheet into a report. In Grade 11 it starts off that way but then towards the end of the year they stop getting the practical sheet, they just get the instructions of the session and then it’s up to them to translate those instructions into a practical report and then in Grade 12 they have to work things themselves.”*

The Chemistry teacher only mentioned telling them verbally the specific components he would expect:

*“After the practical part is over I usually tell them specifically what components I would want particularly when it comes to the conclusion bit because normally the conclusion carries the bulk of the marks of the assessment of the report so I usually tell them what I specifically want particularly when it comes to the explanation of the results and if I want additional information.”*

#### 4.14.3 The Sort of Results Included

Chin-Chung (2003) noted that students may often focus on the ‘aims’ of laboratory activities, but not their ‘purposes’. In other words, students try to see or determine the expected results from the activities *per se*, but they do not invest much mental engagement in relating other learning experiences to laboratory work. Wickman and Ostman (2002) noted that often teachers either ‘talk their way through it’ or ‘rig’ or ‘conjure’ to produce desired results from their experiments or demonstrations. Tables 4.42 and 4.43 show what kind of results were included in their reports, whether they were the results obtained (whether corrected by the teacher or not) or expected results.

**Table 4.42: In the report what kind of results do you include? (Science Students)**

	Grade 8 (n = 93)			Grade 9 (n = 82)			Science Totals (n = 175)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
<b>A</b>	30	27	<b>57</b>	35	17	<b>52</b>	65	44	<b>109</b>
<b>B</b>	11	4	<b>15</b>	7	6	<b>13</b>	18	10	<b>28</b>
<b>C</b>	11	10	<b>21</b>	10	7	<b>17</b>	21	17	<b>38</b>

**Key for Table 4.42**

A - Results you obtained from the experiment

B - Your results which have been corrected/modified by the teacher

C - Expected results – what was supposed to happen

**Table 4.43: In the report what kind of results do you include? (Grades 10-12)**

	Biology (n=135)				Chemistry (n=83)				Physics (n=159)			
	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total
<b>A</b>	34	37	36	<b>107</b>	24	22	20	<b>66</b>	35	55	41	<b>131</b>
<b>B</b>	6	7	10	<b>23</b>	3	4	2	<b>9</b>	10	13	6	<b>29</b>
<b>C</b>	14	8	10	<b>32</b>	11	3	6	<b>20</b>	7	5	8	<b>20</b>

**Key for Table 4.43**

A - Results you obtained from the experiment

B - Your results which have been corrected/modified by the teacher

C - Expected results – what was supposed to happen

While students usually included the results from their own experiment, a significant percentage of students said they included expected results as opposed to the results obtained. This was frequently noted in all subjects except Physics where only 11.1% of students said they included expected results (the other subjects averaging double that). Corrected results were the least included across all subjects except Physics. The overall percentage of students including their own results increased steadily by grade, reaching a peak in Grade 11 before dipping slightly in Grade 12. In fact in Grade 11 only 10.4% of the students included expected results. The Biology teacher confirmed this:

*“Well they generally write their own results. If the results are incorrect they are expected to discuss the expected results how they should have been and the reason for why the results were not exact.”*

#### 4.14.4 The Importance of the Different Parts of the Report

It is rational to think that if students knew which parts of the report are the most important they would possibly dedicate more time and effort to those sections which in turn would lead to better marks for the report.

**Table 4.44: Which part of the report do you think is the most important? (Science Students)**

	Grade 8 ( <i>n</i> = 92)			Grade 9 ( <i>n</i> = 84)			Science Totals ( <i>n</i> = 176)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
<b>A</b>	5	0	<b>5</b>	3	3	<b>6</b>	8	3	<b>11</b>
<b>B</b>	2	0	<b>2</b>	1	0	<b>1</b>	3	0	<b>3</b>
<b>C</b>	26	19	<b>45</b>	15	11	<b>26</b>	41	30	<b>71</b>
<b>D</b>	4	4	<b>8</b>	13	5	<b>18</b>	17	9	<b>26</b>
<b>E</b>				4	5	<b>9</b>	4	5	<b>9</b>
<b>F</b>	16	16	<b>32</b>	13	11	<b>24</b>	29	27	<b>56</b>

**Key for Table 4.44**  
**A** - Aim      **B** - Apparatus      **C** - Method      **D** - Result      **E** - Conclusion  
**F** - All the same

*Note: Grade 8 students do not have a conclusion in their reports.*

When asked which part of the report they thought was the most important, many Grade 8 and 9 students highlighted the ‘Method’ (48.9% and 31% respectively). Following that the most popular reply for both grades was that they were ‘All the same’ followed by the ‘Result’ (though it must be noted that the percentage indicating ‘Result’ increased by quite a margin in Grade 9). ‘Conclusion’ (for Grade 9), ‘Aim’ and ‘Apparatus’ were the least mentioned. Both genders replied similarly.

From Grade 10 onwards, ‘Method’, ‘Result’, ‘Conclusion’ and ‘Discussion’ were the parts found most important by the students (as can be seen in Table 4.45 and Figure 4.24). The ‘Conclusion’ in particular was deemed the most important by both Chemistry and Physics students (third in Biology). ‘Method’ was also mentioned regularly (tied most with ‘Discussion’ by Biology students) though the ‘Discussion’ was of less importance to the Physics students (11.4%). Of particular interest was the surprisingly high percentage of students (12.9%) who still thought that all areas of the report were equally important. When taking into account what the Chemistry teacher said, “... *the bulk of the marks, basically ten out of fifteen are given to the conclusion and discussion part*”, it was noticed that the older they grew, the more the students gave importance to the parts allocated the most marks. Genderwise, it was noted that in all three subjects, a higher percentage of

females mentioned 'Result' and 'Conclusion' as being most important as opposed to males. Males, with the only exception of Biology (where the results were similar) mentioned 'Method' and 'Discussion' more, while it was also interesting to note that more males than females replied 'All the same' irrespective of subject.

**Table 4.45: Which part of the report do you think is the most important? (Grades 10-12)**

	Biology ( <i>n</i> =230)				Chemistry ( <i>n</i> =123)				Physics ( <i>n</i> =246)			
	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total
<b>A</b>	4	5	4	<b>13</b>	2	1	2	<b>5</b>	4	5	6	<b>15</b>
<b>B</b>	1	1	0	<b>2</b>	0	1	0	<b>1</b>	0	1	0	<b>1</b>
<b>C</b>	19	16	13	<b>48</b>	5	7	5	<b>17</b>	14	23	16	<b>53</b>
<b>D</b>	11	15	13	<b>39</b>	8	9	8	<b>25</b>	13	21	7	<b>41</b>
<b>E</b>	1	4	1	<b>6</b>	2	2	1	<b>5</b>	1	4	3	<b>8</b>
<b>F</b>	2	5	0	<b>7</b>	2	2	0	<b>4</b>	2	5	0	<b>7</b>
<b>G</b>	9	17	17	<b>43</b>	7	9	12	<b>28</b>	14	22	21	<b>57</b>
<b>H</b>	6	22	20	<b>48</b>	5	9	7	<b>21</b>	5	13	10	<b>28</b>
<b>I</b>	8	10	6	<b>24</b>	8	6	3	<b>17</b>	9	17	10	<b>36</b>

**Key for Table 4.45**

**A** - Aim

**B** - Apparatus

**C** - Method

**D** - Result

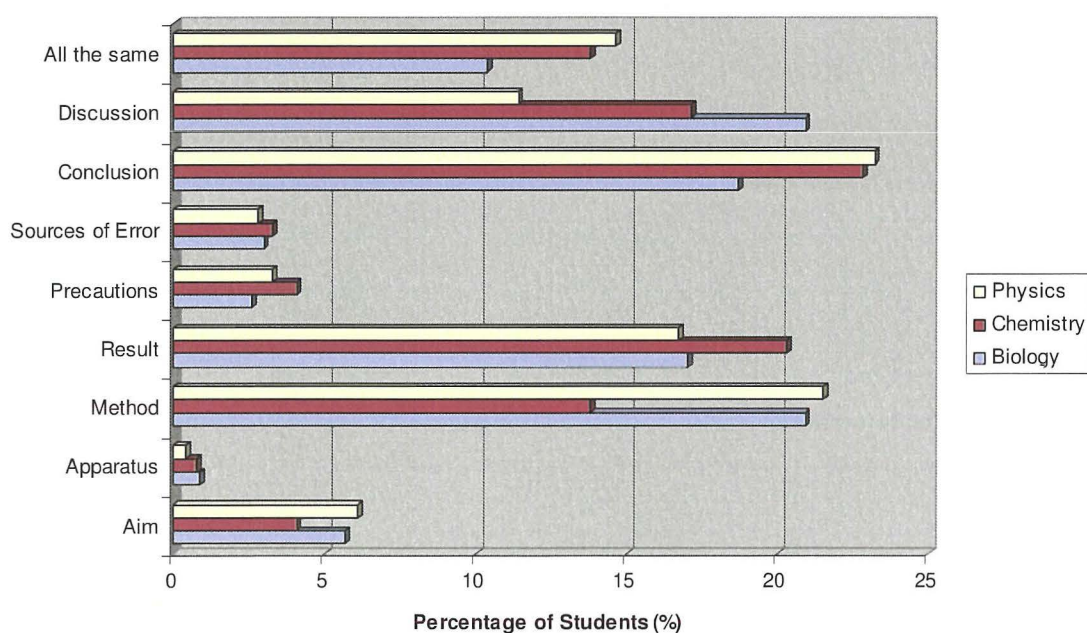
**E** - Precautions

**F** - Sources of Error

**G** - Conclusion

**H** - Discussion

**I** - All the same



**Figure 4.24: Part of the report deemed most important by students (Grades 10-12)**

Students were then asked about which part of the report is the least important. Students' responses are presented in Tables 4.46 and 4.47.

**Table 4.46: Which part of the report do you think is the least important? (Science Students)**

	Grade 8 ( <i>n</i> = 85)			Grade 9 ( <i>n</i> = 77)			Science Totals ( <i>n</i> = 162)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
<b>A</b>	17	18	<b>35</b>	8	6	<b>14</b>	25	24	<b>49</b>
<b>B</b>	10	4	<b>14</b>	12	9	<b>21</b>	22	13	<b>35</b>
<b>C</b>	3	0	<b>3</b>	5	0	<b>5</b>	8	0	<b>8</b>
<b>D</b>	5	1	<b>6</b>	1	1	<b>2</b>	6	2	<b>8</b>
<b>E</b>				12	5	<b>17</b>	12	5	<b>17</b>
<b>F</b>	13	14	<b>27</b>	10	8	<b>18</b>	23	22	<b>45</b>

**Key for Table 4.46**  
**A** - Aim      **B** - Apparatus      **C** - Method      **D** - Result      **E** - Conclusion  
**F** - All the same

'Aim' was the part deemed less important by the Grade 8 students followed by 'All the same' and 'Apparatus'. The situation reversed in Grade 9 with 'Apparatus' being considered the least important followed by 'All the same', 'Conclusion' (not available in Grade 8) and 'Aim'. Out of the few who mentioned 'Method' and 'Result' (deemed most important in the previous question), it was noted that they were all male (no females in either grade listed 'Method').

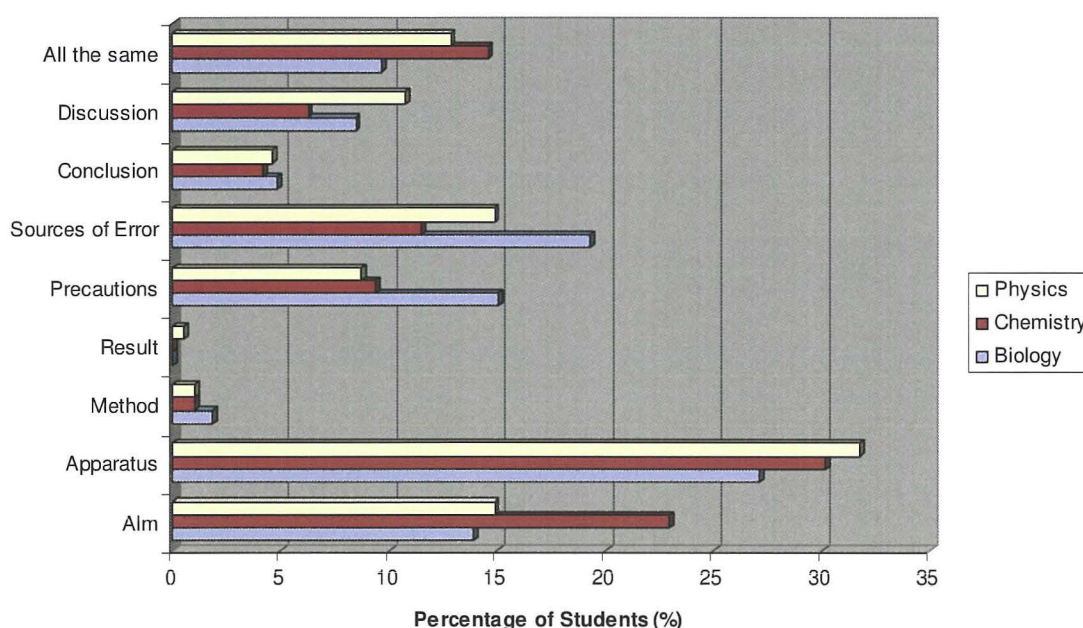
**Table 4.47: Which part of the report do you think is the least important? (Grades 10-12)**

	Biology ( <i>n</i> =166)				Chemistry ( <i>n</i> =96)				Physics ( <i>n</i> =195)			
	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total
<b>A</b>	9	9	5	<b>23</b>	8	8	6	<b>22</b>	8	12	9	<b>29</b>
<b>B</b>	14	19	12	<b>45</b>	10	10	9	<b>29</b>	17	28	17	<b>62</b>
<b>C</b>	1	1	1	<b>3</b>	0	1	0	<b>1</b>	0	1	1	<b>2</b>
<b>D</b>	0	0	0	<b>0</b>	0	0	0	<b>0</b>	0	0	1	<b>1</b>
<b>E</b>	8	6	11	<b>25</b>	2	3	4	<b>9</b>	6	5	6	<b>17</b>
<b>F</b>	4	7	21	<b>32</b>	2	3	6	<b>11</b>	8	8	13	<b>29</b>
<b>G</b>	4	3	1	<b>8</b>	1	2	1	<b>4</b>	2	7	0	<b>9</b>
<b>H</b>	5	5	4	<b>14</b>	3	2	1	<b>6</b>	7	10	4	<b>21</b>
<b>I</b>	4	9	3	<b>16</b>	7	6	1	<b>14</b>	7	11	7	<b>25</b>

**Key for Table 4.47**  
**A** - Aim      **B** - Apparatus      **C** - Method  
**D** - Result      **E** - Precautions      **F** - Sources of Error  
**G** - Conclusion      **H** - Discussion      **I** - All the same

‘Aim’, ‘Apparatus’, ‘Precautions’ and ‘Sources of Error’ were the parts deemed less important by the Grade 10 to 12 students with ‘Apparatus’ being the part mentioned most in all subjects. ‘Precautions’ and ‘Sources of error’ were mentioned more by Biology students than the other subjects while ‘Aim’ was the second most mentioned part by Chemistry students. ‘Discussion’ was also highlighted by the Physics students though not as much by the other students (again mirroring the results obtained in the previous question). Roughly the same percentage of students (12%) replied ‘All the same’ as in the previous question. Looking at the results by gender, a larger percentage of females mentioned ‘Aim’, whereas males mentioned ‘Conclusion’ and ‘Discussion’ more often. This was noticed across all subjects.

The parts of the report the students deemed the least important are represented in Figure 4.25.



**Figure 4.25: Part of the report deemed least important by students (Grades 10-12)**

When asked whether each part of the report is equally important the Physics teachers both said that a lot of importance is given to the results, precautions, sources of error and the conclusion. Likewise the Chemistry teacher gives “*the bulk of the marks basically ten out of fifteen to the result parts and to the conclusion/discussion part.*” In Biology it depends according to the grade:

*“At the beginning when they have the instructions written in front of them and it’s easily translated into a report, things like aim, apparatus, method are not*

*that important however for example in the investigative practicals were they have to come up with their own methodology then it becomes important.”*

The General Science teacher said that the most important parts in Grade 8 and 9 are the method and result. This shows that most students recognise the parts which are the most important.

The Science teachers mutually agreed that reports should be given marks as “*there has to be some form of assessment because otherwise teachers wouldn’t have enough feedback as to whether the practical report and the practical would have been effective or not*” (Chemistry teacher). Likewise teachers agreed that marks should be given to the actual practical besides the report. The Biology teacher however said that these marks should be added to the already existing marks so that no marks would be taken away from where they are already allocated.

It can be seen that most students know which parts of the report are the most important and this could explain the relatively high marks most students obtain in their report as seen in Tables 4.48 and 4.49 where students were asked for the average mark obtained for their reports. Those students obtaining low marks may need further guidance as to what is considered the most important by teachers when marking.

**Table 4.48: On average how many marks do you usually obtain for your report? (Science Students)**

	Grade 8 (n = 81)			Grade 9 (n = 74)			Science Totals (n = 155)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
<b>A</b>	39	33	<b>72</b>	36	24	<b>60</b>	75	57	<b>132</b>
<b>B</b>	4	3	<b>7</b>	10	2	<b>12</b>	14	5	<b>19</b>
<b>C</b>	1	1	<b>2</b>	0	2	<b>2</b>	1	3	<b>4</b>

**Key for Table 4.48**

A - 8 to 10

B - 5 to 7

C - 4 or less

**Table 4.49: On average how many marks do you usually obtain for your report? (Grades 10-12)**

	Biology (n=136)				Chemistry (n=83)				Physics (n=159)			
	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total
<b>A</b>	37	32	35	<b>104</b>	23	24	21	<b>68</b>	41	49	42	<b>132</b>
<b>B</b>	7	12	12	<b>31</b>	7	3	5	<b>15</b>	5	14	6	<b>25</b>
<b>C</b>	1	0	0	<b>1</b>	0	0	0	<b>0</b>	1	0	1	<b>2</b>

**Key for Table 4.49**

A - 13 to 15

B - 9 to 12

C - 8 or less

Students seem to be doing well in all grades and subjects with the majority claiming to regularly getting close to full marks. Only a small percentage of students claim to get failing marks. The percentage of students getting failing marks falls from an average of 2.6% in Grades 8 and 9, to 0.8% by Grade 12 (in Grade 11 no students reported getting failing marks). Physics students seem to be getting the highest overall marks in their reports followed by Chemistry and Biology. Both Biology and Physics students perform best in Grade 10 and worst in Grade 11, the exact opposite of Chemistry students. As regards to gender, a higher percentage of females in each grade reported getting close to full marks as opposed to males. When examining the results by subject, females again seemed to fare better with the only exception being Chemistry where males fared best. In line with this, Frost et. al (2005) believes that extended written accounts such as reports favour traditionally female-like ways of writing.

Notwithstanding what students said earlier about which parts are more or less important when writing a report, they were asked whether they think different parts of the report should be allocated different amount of marks. A summary of their replies are shown in Tables 4.50 and 4.51.

**Table 4.50: Should each part of the report be equally important when calculating the final mark? (Science Students)**

	Grade 8 ( <i>n</i> = 79)			Grade 9 ( <i>n</i> = 76)			Science Totals ( <i>n</i> = 155)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
<b>A</b>	26	21	<b>47</b>	24	17	<b>41</b>	50	38	<b>88</b>
<b>B</b>	18	14	<b>32</b>	23	12	<b>35</b>	41	26	<b>67</b>

**Key for Table 4.50**

A – Each part equally important

B – Some parts more important than others

**Table 4.51: Should each part of the report be equally important when calculating the final mark? (Grades 10-12)**

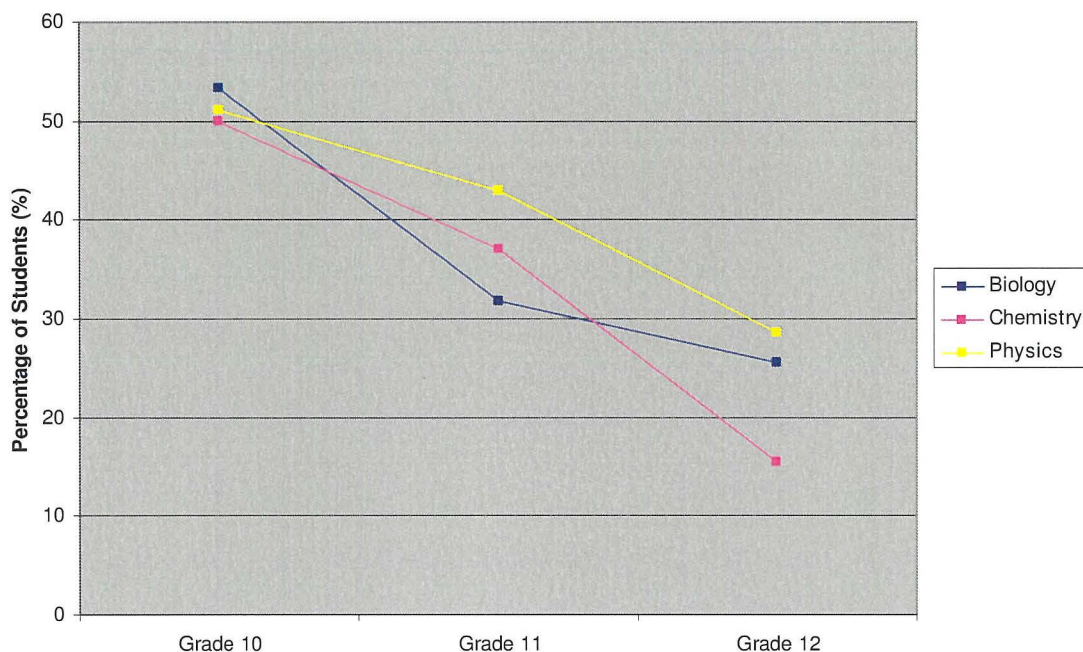
	Biology ( <i>n</i> =136)				Chemistry ( <i>n</i> =83)				Physics ( <i>n</i> =159)			
	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total
<b>A</b>	24	14	12	<b>50</b>	15	10	4	<b>29</b>	24	27	14	<b>65</b>
<b>B</b>	21	30	35	<b>86</b>	15	17	22	<b>54</b>	23	36	35	<b>94</b>

**Key for Table 4.51**

A – Each part equally important

B – Some parts more important than others

As students progressed from one grade to another, fewer students said that each part of the report was equally important when calculating the final mark (as illustrated in Figure 4.26). This implies that as the students get older they become more aware of the different value of each part. Having said that, this distinction was noticed more in Chemistry students than Physics students (Biology coming second) where by Grade 12 just 15.4% of Chemistry students felt each part was equally important as opposed to 28.6% of Physics students.



**Figure 4.26: Percentage of students who feel each part of the report is equally important when calculating the final mark by Grade**

When asked for reasons for their answer in the previous question, most students who felt each part was equally important said that the report would be incomplete without any of its parts, making each part important. A Grade 8 girl said that “*the method, for example, is as important as the result because a mistake can produce a different result*”. A similar view was held by a Grade 11 girl who said “*if one calculation is wrong, chances are the other things like the graph will also be wrong*”.

Most of the students who felt some parts were more important than others specified that parts such as the method, discussion, result and conclusion (parts highlighted as being the most important by students in a previous question) were much more important than say, apparatus. Some students also commented that the different level of difficulty posed by each part should be marked accordingly. On the same note, a Grade 11 girl said that “*although you need to know everything since all is important, the discussion and*

*conclusion should hold more marks since they are longer and more time consuming.*” A Grade 11 boy simply stated that *“10/15 of the marks are from the conclusion.”*

When the teachers were asked whether they allow students to redo a report if they did not do so well in it, they gave different answers. While the General Science teacher said that they can, one of the Physics teachers said that students are not allowed to redo the report *“because you’re given enough time to do that so that cannot be redone”*. The other Physics teacher however, said that students are allowed to arrange a report *“if the results are drastically wrong and the student is eager to arrange”*. The Chemistry teacher said that redoing the report is discouraged because of MATSEC restrictions however, *“there have been exceptional instances where they were allowed to redo a practical for some reason or another.”* The Biology teacher said that they are only allowed to redo it *“once, immediately following the correction.”*

#### 4.15 Marking the Report

Reports in all grades are corrected and given marks. In Grades 8 and 9, students are given marks out of ten, while from Grade 10 onwards marks are out of fifteen. Fifteen of the reports done from Grade 10 onwards will contribute to the students’ SEC level examinations if students choose to sit for it. This may add pressure on students to produce better quality work and therefore students were asked whether marks should in fact be given to reports.

**Table 4.52: Should marks be given for reports? (Science Students)**

	Grade 8 (n = 82)			Grade 9 (n = 76)			Science Totals (n = 158)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
<b>A</b>	38	32	<b>70</b>	39	25	<b>64</b>	77	57	<b>134</b>
<b>B</b>	7	5	<b>12</b>	8	4	<b>12</b>	15	9	<b>24</b>

**Key for Table 4.52**

A - Yes

B - No

Table 4.53: Should marks be given for reports? (Grades 10-12)

	Biology (n=136)				Chemistry (n=83)				Physics (n=159)			
	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total
<b>A</b>	38	40	41	<b>119</b>	22	24	22	<b>68</b>	39	56	43	<b>138</b>
<b>B</b>	7	4	6	<b>17</b>	8	3	4	<b>15</b>	8	7	6	<b>21</b>

**Key for Table 4.53**  
A - Yes      B - No

When asked whether marks should be given for reports, the answer was a resounding yes across the board (85.6%). The lowest percentage recorded was in Grade 10 Chemistry with 73.3% of the students giving positive replies, all the others surpassing 83%. Of particular interest in this question was that a bigger percentage of females, irrespective of grade or subject replied ‘Yes’ than males (the only exception being Grade 12 Chemistry where an equal number replied ‘Yes’) as seen in Figure 4.27.

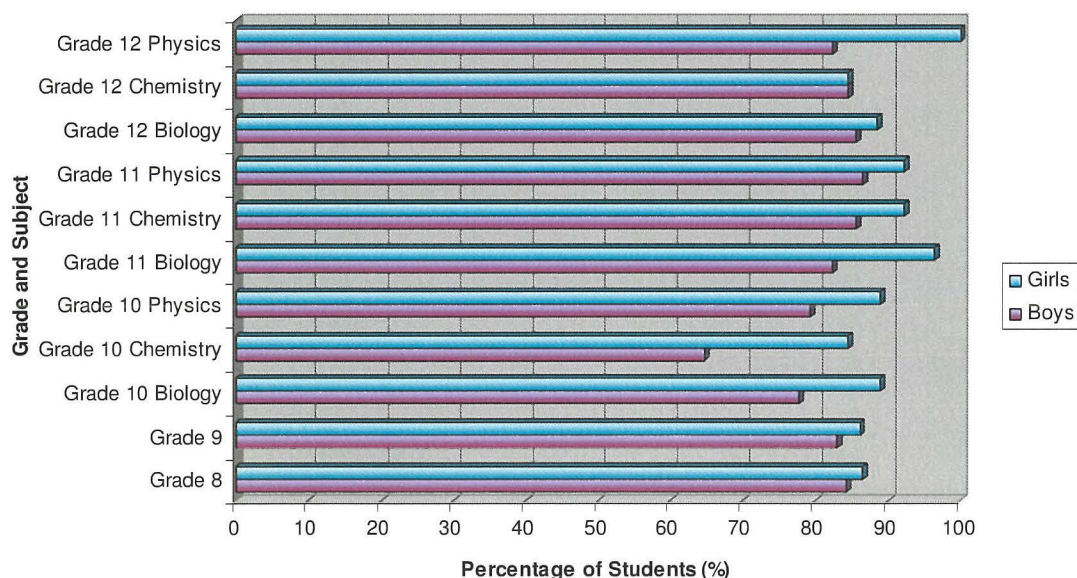


Figure 4.27: Percentage of Students who think marks should be given for reports by Grade and Subject

When asked to give a reason for their answer to the previous question, students who said marks should be given for a report, felt that the mark obtained was the best indication of how they performed during the experiment. A Grade 8 girl commented that thanks to the mark “we can know what our teacher thinks of our work and how we can improve it.” A Grade 9 boy said that during marking the teacher would highlight what he did wrong and correct his work helping him see where he went wrong. Of those who said marks should not be given for the report, a few Science students mentioned that they felt the reports

*“have nothing to do with what you learnt, just copying.”* On a similar note, a Grade 8 boy mentioned it was quite easy to copy the report negating the value of the mark. A Grade 8 girl also mentioned that she did not like the fact that they were *“marked on the reports and nothing else”* wishing the mark to reflect the overall experiment not just the report.

The older students who said marks should be given, placed a bigger focus on the fact that the marks obtained contributed to the overall SEC grade and most felt these were easy marks to obtain. One Grade 11 girl mentioned that the marks obtained throughout the year could help offset doing badly in the final exam. This very same remark though was also used by those who did not want marks given saying it could work the other way round with the report mark adversely affecting their MATSEC grade. A number of students who believe marks should be given also mentioned that the marking system gave them an added incentive to perform better during the experiments and try harder next time in case of a low mark. Others felt they deserved a mark due to the *“effort involved”* in writing the report. Finally among those who did not want marks for reports, a Grade 11 boy said *“no, because I believe application and analytical questions in the exam paper are more important.”*

The Science teachers said that reports are written for all the experiments done, the exception being when demonstrations are carried out or if the experiment is too small/short to be written up. The teachers ask students to present the work in a similar format:

*“It is basically always the same which is aim, apparatus, method, diagram, table, results, conclusion and research, that’s the order. The only thing is there are some practicals that apart from the results we also have calculations and graphs, so in that case precautions and sources of error would apply.”*

(Physics teacher)

The mark given for the report does not cover the skills used while doing a practical. The General Science teacher said that *“in Grade 8 and 9 I don’t think so”* which once again is surprising considering that the syllabus focuses on skills and there is nothing to restrict them. In Chemistry it is used to the minimum *“because in the chemistry syllabus it doesn’t actually specify this so I feel it will be unfair to remove marks when other schools definitely do not”*. The Biology teacher, on the other hand, marks skills through the system available in that experiments which require observation and drawing skills will be given marks on the diagram which in turn is assessing skills.

Within Biology, Chemistry and Physics laboratory work is assessed with marks. The distribution of marks is similar in the three subjects. In Physics the marks are basically split up “5 for the method, 5 for results and 5 for conclusion”. Likewise, for Chemistry “around five marks should be allotted to elements like presentation, like the title, the apparatus, the method and so on, and ten given to the results”. What is certain is that most marks are allotted to the result and conclusion (and discussion in the case of Biology). Marks therefore are not allocated for the actual practicals. Students were asked whether they agree with this and responded as shown in Tables 4.54 and 4.55.

**Table 4.54: Do you think marks should be given for the actual practical besides the report? (Science Students)**

	Grade 8 (n = 80)			Grade 9 (n = 76)			Science Totals (n = 156)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
<b>A</b>	24	14	<b>38</b>	24	17	<b>41</b>	48	31	<b>79</b>
<b>B</b>	20	22	<b>42</b>	23	12	<b>35</b>	43	34	<b>77</b>

**Key for Table 4.54**

A - Yes                      B - No

**Table 4.55: Do you think marks should be given for the actual practical besides the report? (Grades 10-12)**

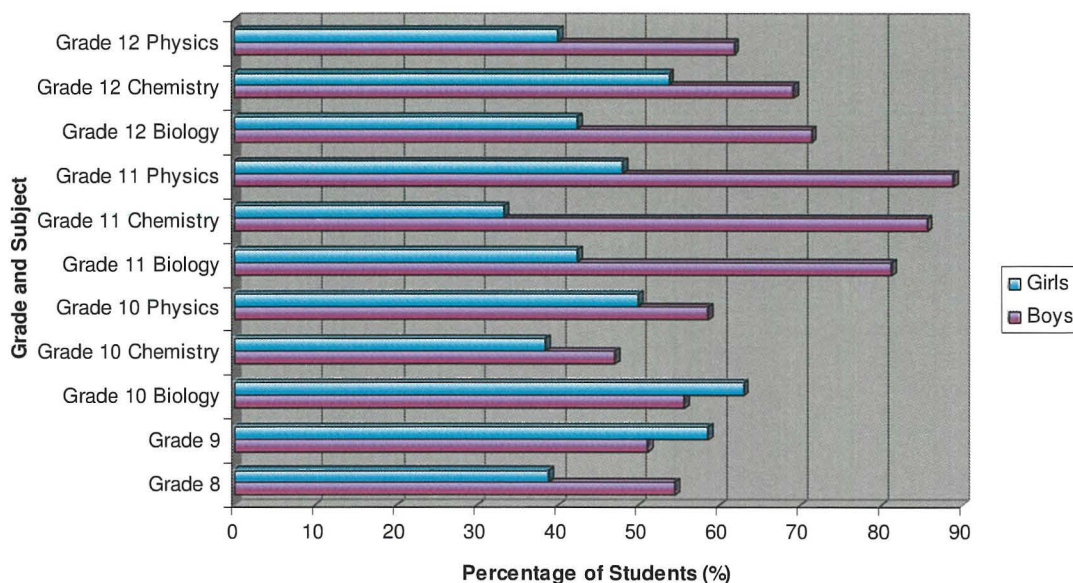
	Biology (n=134)				Chemistry (n=82)				Physics (n=157)			
	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total
<b>A</b>	27	24	26	<b>77</b>	13	16	16	<b>45</b>	26	44	27	<b>97</b>
<b>B</b>	18	18	21	<b>57</b>	17	10	10	<b>37</b>	21	17	22	<b>60</b>

**Key for Table 4.55**

A - Yes                      B - No

When asked whether marks should be given for the actual practical besides the report, students seemed to be divided (Figure 4.28). In Grade 8, 47.5% of the students replied ‘Yes’. While the percentage of students who said ‘Yes’ increased from one grade to the next (peaking at 65.1% in Grade 11 before dipping back to 56.6% in Grade 12), it was only in Grade 11 where there was a pronounced leaning towards one side. Grade 9 and 10 students gave 53.9% and 54.1% positive responses respectively. Physics students had the most positive responses with 61.8% saying ‘Yes’ followed by Biology (57.5%) and Chemistry (54.9%). Taking a look at the replies by gender, with the exception of Grade 9 where 58.6% of girls replied ‘Yes’ as opposed to 51.1% of boys, boys systematically replied ‘Yes’ more than girls. The difference was largest in Grade 11 where 86.4% of boys

replied ‘Yes’ with only 42.9% of girls replying likewise. This discrepancy might indicate that boys are more comfortable than girls with the actual experiment than to the report writing and vice versa. This may be because boys are better than girls in using apparatus (Murphy, 1994) and girls do better than boys in writing reports (Frost et al., 2005).



**Figure 4.28: Percentage of Students who think marks should be given for the actual practical besides the report by Grade and Subject**

Some of the teachers however claim to assess the skills involved during laboratory exercises such as:

*“The student’s ability to logically write down on paper what went on during the session, what materials were used, how they were used, what results were obtained, what results obtained mean, whether there were any parts of the practical session or setup which conveyed errors or erroneous parameters and results.”*

(Biology teacher)

The Physics teacher also mentioned:

*“That they know how to present results in a table, also the graph, they know how to plot the graph, fill the whole page and the calculations then from the graph, the gradient.”*

From Grade 10 onwards, the average marks for the reports are part of the annual examination mark in the school under investigation. Students were asked whether they agreed with this.

**Table 4.56: Should the average marks for reports be part of the annual examination mark? (Science Students)**

	Grade 8 ( <i>n</i> = 80)			Grade 9 ( <i>n</i> = 77)			Science Totals ( <i>n</i> = 157)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
<b>A</b>	19	20	<b>39</b>	23	14	<b>37</b>	42	34	<b>76</b>
<b>B</b>	25	16	<b>41</b>	25	15	<b>40</b>	50	31	<b>81</b>

**Key for Table 4.56**

A - Yes      B - No

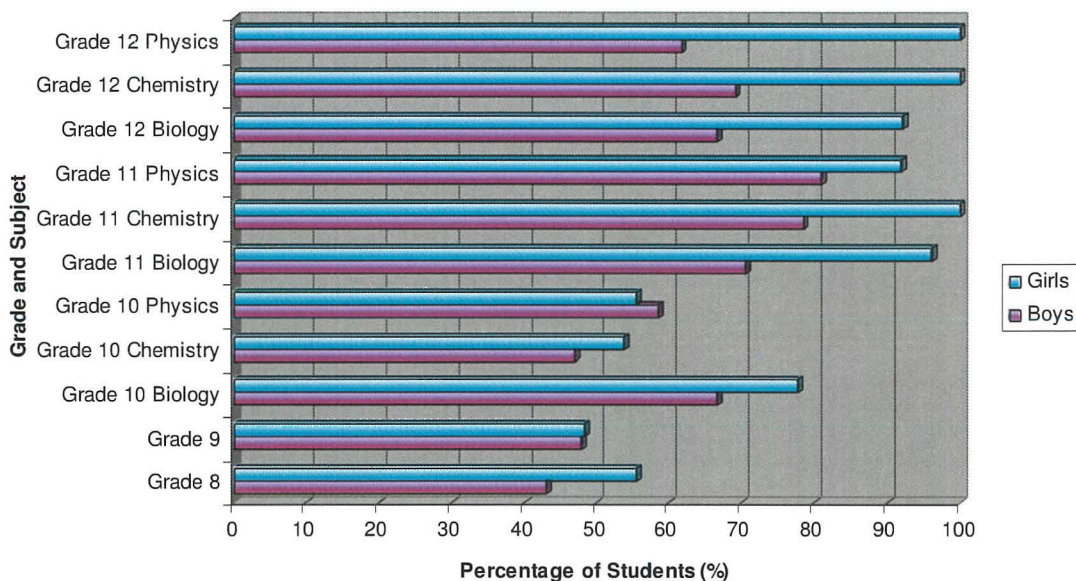
**Table 4.57: Should the average marks for reports be part of the annual examination mark? (Grades 10-12)**

	Biology ( <i>n</i> =135)				Chemistry ( <i>n</i> =82)				Physics ( <i>n</i> =158)			
	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total	Grade 10	Grade 11	Grade 12	Total
<b>A</b>	33	37	38	<b>108</b>	15	23	22	<b>60</b>	27	53	36	<b>116</b>
<b>B</b>	12	6	9	<b>27</b>	15	3	4	<b>22</b>	20	9	13	<b>42</b>

**Key for Table 4.57**

A - Yes      B - No

When asked whether the average marks for reports should be part of the annual examination mark, slightly less than half of the Grade 8 and 9 students (48.8% and 48.1% respectively) replied 'Yes'. This percentage increased to 61.5% in Grade 10, peaked at 86.3% in Grade 11 before dipping to 78.7% in Grade 12. The difference in opinion between the Science students and those in higher grades might be influenced by the fact that from Grade 10 onwards the average marks for reports are part of the annual examination mark. While a similar number of Chemistry and Physics students replied 'Yes' (73.2% and 73.4%), 80% of Biology students replied in the same way. Likewise Nott and Wellington (1999) also report that most students thought investigations were useful in getting good grades in science. Taking a look at gender, in contrast to the previous question, a bigger percentage of females replied 'Yes' than males in all grades and subjects (only exception being Grade 10 Physics where 58.6% of males replied 'Yes' to the 55.6% of females). This could be another indication that girls are more confident in their report writing, while boys might prefer an examination setting. This can be seen in Figure 4.29.



**Figure 4.29: Percentage of Students who think average marks for reports should be part of the annual examination mark by Grade and Subject**

When the same question was posed to the teachers they were all in agreement that the average mark of reports should be part of the annual examinations mark. Both the Physics teachers said that this was actually already in place at the school with one of them saying that 10% of the examination mark in Grade 10 and 15% of the mark in Grades 11 and 12 were taken as the average mark of the reports. When asked why, the other Physics teacher said that besides giving greater importance to the practicals which she felt helped the students a lot in understanding the subject, the students themselves got used early to the fact that the report marks would affect their SEC grade. This point was also mentioned by the Biology teacher, saying that 15% of the SEC grade was based on the practical reports and he felt that the earlier they got used to the system the better. The Chemistry teacher said that for most of the fifteen years he had been at the school he had applied this rule irrespective of which subject he had been teaching. He also mentioned that a couple of years ago this practice was also taken up by state schools, further emphasizing the view that it was the right way to go.

#### 4.16 Suggestions for Improvement

When asked how experiments could be improved, most of the students said they felt they are fine as they are. The major point which was already highlighted in previous questions, seemed to be the report writing with most students wishing this part to be cut out completely or at least reduced. A Grade 10 male student said *“I think the report is not*

*necessary, it's the learning part which is important*". Others said that while reports could not be completely removed, a lesser percentage of the overall mark should be placed on the report and more on the experiment as a whole.

Another point, mentioned mostly by the younger students (Grades 8 and 9), was that they would prefer if they could choose their own partners while doing experiments. This was not mentioned directly by students in the higher grades where it did not seem to be an issue. What became an issue though, in higher grades, was the SEC examination with a number of students wishing the experiment would not have a bearing on the SEC examination mark. This seemed to add a level of stress to the students reducing their enjoyment of the experiments. Better and more apparatus was also mentioned by most students, with Physics students in particular wanting groups to be smaller in number (a consequence of not having enough apparatus).

Finally a significant number of Grade 10 to 12 students, irrespective of subject, mentioned they would prefer better explanations of the experiments saying they sometimes seemed a bit hurried. With the same number of students wishing more time to actually perform the experiments, it was obvious that time was a major issue during both the explanation and practical phases. This was also mentioned by the teachers themselves during the interviews where the overall reaction seemed to be that they had to make do with the little time they had allocated.

Teachers mentioned that the syllabus should be diluted so that they would have more time for experiments; not necessarily experiments aimed for the examination but "*fun experiments where the students can enjoy themselves*" (General Science teacher). The Physics teachers also added that practicals can be improved by having fewer students per class. She also mentioned that "*there should be a longer period for practicals, more time so that we don't have 1½ hours during which we have to do everything.*" All teachers also mentioned having better apparatus "*you can have better equipment like more state of the art equipment, more expensive equipment*" (Biology teacher).

#### **4.17 Conclusion**

This study has revealed some implications for teaching and classroom practice. The results and analysis have the potential of helping teachers develop their awareness about how

students perceive practicals. Teachers can be encouraged to examine the strengths and weaknesses of their own teaching, which can be viewed as a way of facilitating professional development. These implications will be discussed in the next chapter.

## **Chapter 5**

### Conclusions and Some Implications

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## 5.1 Introduction

The purpose of this final chapter is to present the major findings of the research and to suggest some improvements for practicals in the school under study. The limitations of the study are discussed and followed by some suggestions for further research. The dissertation then comes to an end with the conclusion which reviews whether the aims of the research were achieved.

## 5.2 Major Findings of the Study

In this section the major findings are addressed within the original intention of the study. The main aim of the study was to understand student perceptions of practicals in science education within a particular school. The questionnaire was given to all the students in the school and the responses were analysed in terms of how students' perceptions differ with grade, gender and subject. Teachers were then interviewed for their views about practicals, which were matched with those of students.

### 1. What are students' perceptions of practicals? How do students' perceptions of practicals differ as they progress academically?

Students and teachers alike presented cognitive, affective and skills arguments as reasons why experiments were carried out. This indicates that students find practicals beneficial to their studies as some think that experiments are done to learn how to do something and to see how things work. Others said that experiments help them understand concepts and prove what is learnt in class. Students said that experiments teach them the relevance of science to real life and provide opportunities for hands-on experience in handling apparatus and materials. Students think experiments are done so that they can have fun and in order that they can be like real scientists. From Grade 10 onwards some students mentioned that experiments were done because of their SEC-level examination.

Irrespective of grade, gender and subject, students seem to find experiments helpful to understand the subject and most students thought that practicals help them perform better in examinations because experiments are easier to remember than theory. Students felt that

experiments helped them understand concepts better and noted that questions related to experiments were often asked in examinations.

Most teachers shared the view that practicals help students in examinations, however, some believed that they do not make a difference or are of no benefit to performance in examinations. Students who shared this view stated that experiments could be a distraction and take time away from theory or explanation time. Experiments also increased the amount of work needed to study for examinations. However, with the exception of students in Grade 10 Chemistry (32.3%) and Grade 12 Biology (39.9%) the number of students who held this view was relatively small. As seen in Chapter 4, practicals are important for the examination and therefore teachers and students should be aware of it, possibly by stating it clearly in the syllabi.

Students were asked about the difficulty of the experiments given. In Grades 8 and 9 males found the level of difficulty of the tasks given during experiments slightly lower than their female counterparts. Chemistry experiments are seen as the most difficult by the students followed by the Biology experiments, Physics being easiest. In Grades 10-12 females seemed to find practical sessions easier overall than males.

When students were asked whether they feel practicals become more difficult over the years, Grade 9 students did not experience a big change in difficulty. However, in Biology, Chemistry and Physics, more than half the students noticed an increase in difficulty as the years go by.

Students mentioned a number of factors which they thought made an experiment memorable. Students mentioned it being fun, easy and interesting. Students remember an experiment better if they could relate it to their lives and if they thought it could be helpful in the future. Experiments are remembered better if something is learnt from them and if they involve something unusual or enjoyable. Students remember those experiments that they carried out with friends. There were no differences in opinion between gender. When planning practicals teachers may note these factors.

Working in pairs was preferred across all subjects (the only exception being Grade 10 students who preferred group work) while working individually was the least preferred. All teachers said that practicals were mainly carried out in pairs or groups, while individual

work is only used for some Biology experiments. Choosing how students work depended on the amount of time and apparatus available. Teachers also thought that students working in groups help each other out.

Students are also encouraged to pool results and this is done to work out an average to obtain reliable results and when students carry out surveys.

Students were asked which order they would prefer to learn, either first covering the theory then the experiment or vice versa. Most students replied that they preferred covering theory first and then doing the experiment (the only exception being Grade 9). This indicates that students prefer knowing what is going on during the experiment rather than delving into the unknown. All the teachers mentioned that the order varies depending on the topic being taught.

## **2. Are students satisfied with the amount of practical work done?**

The amount of practical work carried out decreases from Grade 8 to Grade 12. Despite this, most students regardless of grade are satisfied with the amount of practical work done. This indicates that once the novelty has worn out practicals become less appealing and therefore teachers need to reassess the practicals carried out or use other alternatives to practicals as students get older. Both the Biology and Chemistry teachers indicated that they would like to increase the amount of practical sessions done and one Physics teacher just indicated that she would like to increase the amount of practical sessions in Grade 12.

## **3. What do students think are the factors that make a 'good experiment'?**

Students and teachers think that the main factors that make a good experiment are when the experiment is fun, interesting and exciting and when the experiment helps them understand the theory. Instructions which are clear and easy to understand and follow are important factors that make a good experiment and so is a good explanation by the teacher. During a good experiment, good quality apparatus should be provided, safety must be assured and good results obtained. A good experiment is also one which the students performed themselves.

#### **4. How are students given instructions and how can they be improved?**

In general students seemed to have a good understanding of both the aim of the experiment and what went on during an experiment. Most students also claimed understanding the instructions given for practical work irrespective of grade, gender or type of instructions given.

'Handouts' were the most widely used type of help given to Science students and Biology students. While 'Handouts' were also given to Chemistry and Physics students, 'Teacher dictations' were more prevalent in these subjects.

Students in higher grades design experiments themselves more often than students in Grades 8 and 9. Ironically, when students were asked which type of experiment they would prefer 'Designing your own experiment' was a very popular choice with Science students. Its popularity however, plummeted from Grade 10 onwards whereas 'Following a given set of instructions' shot up to be the most popular in all subsequent grades. Therefore it seems that younger students who do not have a lot of opportunity to design their own experiment imagine that they would enjoy it but once they are able to do more of it (Grade 10 onwards) they do not appreciate it a lot. This seems to imply that designing an experiment is not presented in a form that students find attractive or worth the extra effort. Those students who preferred designing their own experiments find these experiments more fun; it gives them a greater sense of accomplishment and they are easier to remember. The overriding reason given by those students who prefer following instructions was that it minimised mistakes and was easier to do. Better understanding was the main point given by those students who would prefer teacher demonstrations. It seems that lack of confidence is found in both males and females and especially so in those studying Chemistry.

#### **5. What do students think the purpose of report writing is and do they think that the marking scheme is fair?**

Most students in all grades believe that report writing helps them understand the experiment better.

The majority of both Grade 8 and 9 students highlighted the 'Method' as the most important part of the report. From Grade 10 onwards, 'Method', 'Result', 'Conclusion' and 'Discussion' were the parts found most important by the students. Of particular interest was the surprisingly high percentage of students who thought that all areas of the report were equally important.

Students were also asked which part of the report is the least important. The 'Aim' was the part deemed less important by the Grade 8 students followed by 'All the same' and 'Apparatus'. In Grade 9 with 'Apparatus' being considered the least important followed by 'All the same', 'Conclusion' and 'Aim'. The Grade 10 to 12 students deemed the 'Aim', 'Apparatus', 'Precautions' and 'Sources of Error' as the least important parts of the report.

In spite of the uncertainty as to which part of the report is the most/least important, in their written reports students seem to be doing well in all grades and subjects with the majority claiming to regularly getting close to full marks. The uncertainty noted above may be causing students to put a lot of effort in all parts of the report, sometimes more than necessary, resulting in students writing excessively long reports and downloading or copying material from books and websites. It may also be what contributes to the students' negative image of report writing.

Students claim to include the results from their own experiment although, a significant percentage of students said they wrote expected results. The percentage of students including their own results increased steadily by grade, reaching a peak in Grade 11 before dipping slightly in Grade 12. Having to include their own results may be one of the reasons why students prefer following a set of instructions as opposed to designing their own experiment, as the set of instructions increase the likelihood of obtaining a correct result.

## **6. Which are the things that make experiments enjoyable or not for students?**

Overall students seem to enjoy practical work, however, there is a steady decrease in the level of enjoyment from Grade 8 to Grade 12. Considering Biology, Chemistry and Physics, Physics students seem to enjoy their practical work most overall, however Biology had the lowest number of students saying they did not like the practical sessions.

Students reported a number of factors that make experiments enjoyable. Experiments are enjoyable if they are fun, interesting and if they learn from them. They are enjoyable when they have the opportunity to use apparatus and if they obtain surprising results. Students enjoy experiments as they give them a break from writing and they work with friends. On the downside, students reported that they do not enjoy writing reports and cleaning up.

#### **7. Do students feel like a real scientist when doing experiments?**

It resulted that out of all the grades, only Grade 8 had a majority of students replying that they felt like scientists during the experiments, with all the other grades replying negatively. As regards the higher grades, Chemistry seemed to make the students feel like scientists most. Females replied 'Yes' more than males in all grades and subjects with the only exceptions being Grade 11 Biology and Grade 10 Physics. Surprisingly, teachers believe that the practicals done in class are related to the experiments carried out by professionals.

Those students who reported feeling like a scientist during an experiment attributed wearing of lab coats and goggles as being a factor for them feeling like this. Other factors given were doing the experiment itself and being in a laboratory. Students said performing experiments made them feel intelligent as they are solving something and therefore allowing them to follow in the footsteps of real scientists.

Those students who reported not feeling like a scientist during experiments, attributed this to following step-by-step instructions and not designing the experiment themselves. Students reported not having anything new to prove and the unimportance of the experiment and results obtained as being a significant difference between what they do in the laboratory and the real work of scientists. Experiments done in school laboratories were perceived as too short and easy for real scientists as scientists supposedly do complicated experiments in better equipped laboratories and obtain exciting results.

**8. How do student think experiments can be improved? What changes would secondary school teachers like to see with respect to the laboratory?**

To answer this question, students replied as follows:

- experiments are fine as they are;
- report writing can be cut out completely or at least reduced;
- in examinations a lower percentage of the overall mark to be placed on the report and more on the experiment as a whole;
- the experiment should not have a bearing on the SEC mark;
- if they could choose their own partners while doing experiments;
- having better and more apparatus, all teachers also mentioned having better apparatus;
- Physics students in particular wanted groups to be smaller in number. The Physics teachers also added that practical work can be improved by having fewer students per class;
- having better explanations of the experiments;
- more time to actually perform the experiments, this was mentioned also by a physics teacher.

Teachers mentioned that the syllabus should be diluted to give more time to practical work.

**9. What goals do the teachers of this school have for the laboratory experience?**

This study included investigations of the factors that influence teachers' choice of science experiments and the aims for these experiments. Teachers claimed to carry out a variety of experiments depending on the purpose. When asked which of the four types of practical work is the most important, mixed answers were received. While the Science, Biology and Chemistry teachers said they were all important, the Physics teachers on the other hand had differing opinions, one saying that the investigative experiments were the most important and the other saying that the illustration experiments were the most important. It seems that the different types of experiments have their importance and therefore syllabi need to allow teachers flexibility to choose which experiment is most appropriate.

When asked specifically about designing experiments, teachers claim that these experiments test the students' analytical skills, promote active thinking, increase their attention span and help them remember concepts. Furthermore, in Physics there is a

question in the SEC examination asking students to design an experiment, and thus it is good practice. The teachers' favourable perceptions about designing experiments contrast with the students' responses described earlier. This implies that teachers need to improve the appeal of this type of experiment.

Teachers were asked whether having students present reports for MATSEC restricts them in any way. Though none found it restricting overall, they mentioned factors such as time, the vastness of the syllabus and the marking scheme as restrictive. Some teachers feel restricted as certain outings and investigations are not recognised. The teachers would like marking criteria for practical work to come from the MATSEC board. Different teachers have differing opinions about the guidelines offered by MATSEC, some preferring more restrictions like the marking scheme while others preferring to be able to try new things. Teachers view practicals as being important and would like to see more time dedicated to them in the syllabus.

Teachers view practicals as having social goals, as they encourage collaboration and help create new friendships. Some teachers allow informal discussions during laboratory work as they provide an opportunity for student-student and student-teacher interaction and give the teacher an indication of the ideas the student has. Those teachers who did not allow informal discussions said this was due to time constraints and safety considerations.

### **5.3 Implications and Recommendations for the School**

Hofstein and Lunetta (2003) suggest that objectives for experiments usually differ depending on the experiment. The objectives for students learning outcomes should drive the rationale behind choosing experiments over others. If the experiment is meant to illustrate a theory then the experiment chosen should allow students to easily link the experiments to the theory. If on the other hand the teacher wants the students to apply a concept then an investigation should be done. Students should be helped to understand the purposes for each investigation in a prelab session and once again in postlab reporting and discussion. This would help students acquire a clearer picture of the aim of the practical.

The results indicated factors worth considering when choosing practicals. Students tend to remember experiments more if they are fun, easy and interesting and if they feel they learn something from the experiment. They tend to remember those experiments that are related

to their lives and are helpful to their future. They also remembered those experiments that involve something unusual or involved something they enjoyed.

In situations where theory can be illustrated with practicals, experiments should be performed. The theory and experiment should be done together so students can link the theory with the experiment. Experiments should not be done solely to fulfil the MATSEC requirement but to help students understand concepts better. Covering the theory and then doing the practical seems to help students learn better. Teachers should choose the approach depending on the topic.

A number of instructions for carrying out practicals should be given. These should be given both visually and orally. The teachers of different subjects however, should give the same types of instructions, for example they all give handouts so that students who have more than one science subject will not get confused on what to expect. Teachers should aim to spend more time on the explanation. They should try to speak slowly, give more detail and write instructions on the whiteboard. Teachers should demonstrate experiments especially when it aims to teach skills. Instructions should be illustrated whenever possible, with either a diagram of the steps in the handout or on the board while explaining.

The results indicate that as students proceed to higher grades the tendency is not to want to design practicals themselves. Teachers should attempt to provide experiences that challenge their prior knowledge and existing conceptual frameworks. In higher grades designing practicals can be presented as small projects in which students will be creative in their presentation for example by constructing charts, models, concept maps, and going through role-play and drama presentations.

Another suggestion aimed to appeal to a wider range of students is to incorporate Information and Communications Technology (ICT) into practical lessons. Hofstein and Lunetta (2003) believe that if inquiry empowering technologies are correctly utilised in gathering and analysing data, students will have more time to observe, reflect and construct conceptual knowledge that underlies the practical experience. Furthermore, incorporating appropriate high technology tools can enable students to conduct, interpret and report more complete, accurate and interesting investigations. Such tools can provide a medium for communication, for student-student collaboration, and for the development of a community of learners in the laboratory. Hodson (1998) suggests using simulations and other

computer-based material. Microsoft PowerPoint and Excel and data-loggers also provide a way of using information technology during practicals.

There is a surprising lack of evidence to support the theory that practical work is a more effective means of developing understanding than other activities (Bennett, 2005). For this reason a number of alternative teaching strategies have been put forward. Teachers should be aware of these alternatives so they can choose whether to use a practical or else an alternative activity to reach the aim of the lesson. Activity in the laboratory does not have to directly signify practical. Adams (1991) suggested the use of thought experiments<sup>1</sup> in Physics. Solomon et al. (1992) suggested that students could discuss case studies of particular events in the history of science<sup>2</sup>. Osborne (1998) suggested concept maps, small group work, discussion of instances, DART<sup>3</sup> activities (Directed Activities Related to Texts), writing about science, researching relevant material, using material from newspapers, role plays – none of which require a laboratory.

As indicated in the results the number of students in the laboratory should be small preferably not larger than sixteen. This ensures safety, enough apparatus and individual attention for all students. Students should be allowed to work in pairs during most experiments as it ensures that all students handle apparatus and encourages collaboration. Johnson and Johnson (1999) described five elements that are crucial for effectively implementing cooperative learning: (a) positive interdependence, (b) individual and group accountability, (c) promoting interaction, (d) interpersonal skills and (e) group processing. These should be implemented for all science subjects.

Where possible, informal discussion should be allowed as talking offers an opportunity for conjecture, argument and challenge. Newton et al., (1999) believe that in such a manner,

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<sup>1</sup> A thought experiment is a design of an experiment to test a hypothesis or theory, which cannot actually be carried out due to practical limitations; instead, its purpose is to investigate the potential consequences of the principle in question. Famous examples of thought experiments include Schroedinger's cat and Maxwell's demon.

<sup>2</sup> Teaching through the history of science benefits science education as (a) a better learning of the concepts of science, (b) increased interest and motivation, (c) an introduction to the philosophy of science, (d) a better attitude of the public towards science, and (e) an understanding of the social relevance of science (Solomon et al., 1992).

<sup>3</sup> DARTS describe a variety of ways in which a text may be modified or handled. For example, words could be omitted (close procedure), paragraphs could be reordered (sequencing) or the text could be broken down into instalments (prediction).

knowledge is co-constructed by the group as the group interaction enables the emergence of an understanding whose whole is more than the sum of the individual contributions.

Adequate time should be set aside for practicals. This is the time and opportunity for teachers to interact with their students and also time for students to perform and reflect on complex, investigative tasks (Hofstein and Lunetta, 2003). As Gunstone (1991) has commented,

*“students need to spend more time interacting with ideas and less time interacting with apparatus.”*

(p.74)

The school (which also has a junior sector) should consider introducing practical work at primary level and then attempt ‘bridging’ as suggested by Braund and Driver (2005). In this way students will be exposed to the practical side of science from an early age as it seems that students enjoy experiments a lot when they are younger. By bridging pedagogy between the junior and senior sector, continuity and harmonisation of practical science will be reinforced. Basic skills like reading at eye level and safety procedures can be taught in the junior sector, this will allow teachers of the senior sector to dedicate more time to the concepts being taught without having to dedicate part of the practical session for skills.

Given the great diversity of jobs that require science, practical work as it is done, may be providing a too narrow view of the world of scientists. It may be interesting to take students on outings where they can see scientists at work for example, a forensics laboratory, an electrical company or a research company. In the school laboratory the focus can be on showing students how science is part of our everyday life and is important in many professions such as restoration, engineering and sports-related jobs. For example, experiments that have to do with expansion and contraction in Physics may be used to show how engineers design bridges. Reactions of metals in Chemistry can be used to show how materials are chosen for a purpose depending on their properties. Nutrition in Biology can be used to show how dieticians give advice on diets.

Report writing seems to be the part of practical work that students enjoy the least. The work required in Science reports should form the basis for reports in the higher sciences. Together the science teachers should decide on a format for the reports and how to scaffold the different parts in each grade for example, Grade 8 students would write up to the result,

then in Grade 9 include the conclusion and so on. Having the same format for the higher grades will also reduce confusion for those students who have more than one science subject.

An alternative to decrease the amount of writing would be to create a manual for reports or a series of handouts for the experiments. The emphasis would be on how well they do and understand the experiment rather than how well they write the report. Chin and Kayalvizhi (2005), suggest that it should direct students to focus on various aspects of the investigation such as identifying the purpose, linking to prior knowledge, predicting, explaining and consolidating their knowledge. Smail (1987) suggests that by setting experiments in context by providing background information about the possible uses and applications of scientific principles, experiments are made girl-friendly. Sections of the report which involve simply copying such as the method would be ready on the manual except in practicals where students are asked to design an experiment themselves. The sheets would include direct questions that provide scaffolding which tie the results obtained to the aim of the experiment. Students would be asked to suggest the best way to represent results and would have to include their own results. They should be made aware that an incorrect result does not mean abandonment of theory as it can be used as a focus for discussion. This type of manual/handouts should help students to engage actively in thinking about what they are doing, both in drawing upon their knowledge and understanding, and in their investigative strategies. It helps them to focus on the task at hand, encouraging them to think through concepts and procedures required for the actual conduct of the investigations. This will reduce excessively long discussions that have a lot of material downloaded from the internet. An example of such a handout can be found in Appendix 6. The manual/handouts would include a range of experiments to teach skills, phenomena, investigations as well as some experiences such as fieldwork and site visits. Marks for practical work should continue forming part of the annual examination mark and start forming part of the Grade 8 and 9 examinations to provide a source of continuous assessment.

Marks should be given for the actual experiment when an important part of the experiment would be the skills involved in the experiment. For example, in the preparation of a microscope slide marks should be given for how well the student prepares the slide. If no skills are involved or skills which have been marked in previous experiments then more marks should be dedicated to how well the student can link the theory to the experiment.

The research brought to light the need of continuous professional development for teachers to keep up to date with new and alternative ideas to practical work. Pekmez, et al., (2005), believe that teachers can and will implement innovations effectively and efficiently only if they themselves recognise the need for change and the value of the changes being suggested to them. Long-term and continuous professional development aimed at enhancing science teachers' content knowledge and their pedagogical content knowledge can help teachers develop higher levels of pedagogical and content knowledge, skills, and confidence to construct effective learning environments that include substantive and meaningful science laboratory experiences.

Furthermore, Loucks-Horseley and Matsumoto (1999) state that policy makers often assume that participating in science laboratory work in university courses as part of their course provides teachers with knowledge and skills sufficient to teach successfully in school science laboratories. However in this study teachers expressed the need for more instructions on how to correct practical work. Teachers cannot be expected to mark in the same way if no or limited guidelines are provided. Therefore more training in the form of in-service courses are required or else a marking scheme should be issued. Appendix 7 illustrates an example of an assessment scheme that can be applied to some experiments. If laboratory work instructions and formalised assessment models are developed, they may provide a better basis for assessment and grading of students. The same number of marks should be allotted to the different sections of the report by different teachers. Ottander and Grelsson, (2006) believe that students should be made aware of how the marks are given and that the laboratory manuals are formulated so that these goals are communicated to the students.

#### **5.4 Limitations of the Study**

The study was carried out in a particular school so one should exercise caution before making generalisations, it being a case study.

The study was limited due to time restrictions therefore I had to do a cross-sectional study with the students of a particular year rather than a longitudinal study investigating how the perceptions of students of a particular year change as they progress from year to year.

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## **Appendix 1**

### **Grade 12 Interview Questions**

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## Grade 12 Interview Questions

1. How often do you have practical sessions?
2. Do you consider this to be enough? Why?
3. Why do you think you do experiments?
4. Do you think experiments help you understand Biology/chemistry/physics better?
5. Which order would allow you to learn better? Theory-Practical or Practical-Theory?
6. Which experiment do you remember the most? Why?
7. When you are doing an experiment, do you know why you are doing it?
8. Do you always understand what is happening during the experiment?
9. What sort of instructions are you given? (handout, book, said aloud)
10. Are the instructions clear?
11. Can the instructions be improved? If so, how?
12. Do you find it easy or difficult?
13. Did you expect practical work to be so difficult/easy?
14. Has practical work become more difficult each year?
15. How has practical work changed from grade 8 to grade 12? (Has it become more difficult?)
16. What do you think about report writing?
17. Do reports help you understand the practical work better?
18. Which part of the report is the most important?
19. Which part is the least important?
20. Is the way marks are given fair?
21. Should practical work be assessed (given marks)?
22. Do you think the handling of apparatus should be assessed?
23. What are the things that you do not like about practical work?

24. What are the things that you like about practical work?
25. What are the things that you enjoy doing in the lab?
26. Do you feel like a real scientist when doing experiments?
27. Should the experiment be carried out individually, in pairs, in groups? Why?
28. How can practical work be improved?

## **Appendix 2**

### Questionnaires used for the Pilot Study

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## QUESTIONNAIRE ABOUT PRACTICAL WORK

This questionnaire is about practical work. From the results I hope to find ways how they can be improved.

### Personal Information (*Tick the appropriate box*)

1. Boy                       Girl

2. Grade 8                       9

3. Which subjects are you studying at school?

General science

### General Questions

4. How many practical sessions did you have from October until December? (*Tick  the appropriate box*)

1 – 3

4 – 5

more than 5

5. Using your answer to question 4. Do you consider this to be enough? (*Tick  the appropriate box*)

Yes

No

6. Why do you think practicals are done? (*Write your opinion in the space provided*)

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7. Do you think practicals help you understand the subject better? (*Tick  the appropriate box*)

Yes, help in understanding

No, confuse me

Do not effect learning the subject

8. Which order would allow you to learn better? Covering Theory and then doing the Practical (Theory-Practical) or doing the Practical then covering the Theory (Practical-Theory)? (*Tick  the appropriate box*)

Theory-Practical

Practical-Theory

9. Which practical do you remember the most? (*Write your opinion in the space provided*)

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10. Using your answer to question 9. Give a reason for your choice. (*Write your opinion in the space provided*)

---

---

11. When you are doing a practical, do you understand the aim of the practical (why you are doing it)? (*Tick  the appropriate box*)

Always

Often

Sometimes

Hardly ever

Never

---

12. Do you understand what's happening during the practical? (*Tick  the appropriate box*)

Always

Often

Sometimes

Hardly ever

Never

13. What sort of instructions are you given to follow during a practical? (*Tick  the appropriate box*)

Handouts

Practical cards

Instructions said aloud

Book

Points on the board

Other \_\_\_\_\_

14. Do you understand the instructions given? (*Tick  the appropriate box*)

Always

Often

Sometimes

Hardly ever

Never

15. What can be done to help you understand instructions better? (*Write your opinion in the space provided*)

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16. Would you consider the tasks given during the practical difficult? (*Tick  the appropriate box*)

Always

Often

Sometimes

Hardly ever

Never

17. Has the difficulty of practical work changed? (*Tick  the appropriate box*)

Yes

No

18. If yes how?

More difficult

Less difficult

Remained the same

19. Does writing reports help you understand the practical work better?

Yes

No

20. Which part of the report is the most important? (*Tick  the appropriate box*)

Aim

Apparatus

Method

Result

Conclusion

All the same

---

21. Which part of the report is the least important? (*Tick  the appropriate box*)

Aim

Apparatus

Method

Result

Conclusion

All the same

22. How do you think marks should be given for the difficult parts of the report?  
(*Tick  the appropriate box*)

Each part the same amount of marks?

More marks to certain parts?

23. Explain your answer to the question above. (*Write your opinion in the space provided*)

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24. Do you think that marks should be given for the handling of apparatus during an practical? (*Tick  the appropriate box*)

Yes

No

25. What are the things that you like about practical work? (*Write your opinion in the space provided*)

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26. What are the things that you don't like about practical work? (*Write your opinion in the space provided*)

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27. Do you feel like a real scientist when doing practicals? (*Tick  the appropriate box*)

Yes

No

28. If yes why do you feel like a real scientist when doing the practical?

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29. Should the practical be carried out individually, in pairs, in groups? (*Tick  the appropriate box*)

Individually

Pairs

Groups

30. Explain your answer to question 29. (*Write your opinion in the space provided*)

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31. How can practical work be improved? (*Write your opinion in the space provided*)

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32. Is there anything else that you would like to add about practicals?

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Thanks for your co-operation.

## QUESTIONNAIRE ABOUT PRACTICAL WORK

This questionnaire is about practical work. From the results I hope to find ways how they can be improved.

### Personal Information (Tick the appropriate box)

1. Boy                                   Girl
2. Grade 10                           11                           12
3. Which subjects are you studying at school?  
Biology                           Chemistry                           Physics

### General Questions

4. How many practical sessions did you have between October and December?  
(Tick  the appropriate box)

Biology	Chemistry	Physics
1 – 3 <input type="checkbox"/>	1 – 3 <input type="checkbox"/>	1 – 3 <input type="checkbox"/>
4 – 5 <input type="checkbox"/>	4 – 5 <input type="checkbox"/>	4 – 5 <input type="checkbox"/>
more than 5 <input type="checkbox"/>	more than 5 <input type="checkbox"/>	more than 5 <input type="checkbox"/>

5. Using your answer to question 4. Do you consider this to be enough?  
(Tick  the appropriate box)

Biology	Chemistry	Physics
enough <input type="checkbox"/>	enough <input type="checkbox"/>	enough <input type="checkbox"/>
too little <input type="checkbox"/>	too little <input type="checkbox"/>	too little <input type="checkbox"/>
too many <input type="checkbox"/>	too many <input type="checkbox"/>	too many <input type="checkbox"/>

6. Why do you think experiments are done? (Write your opinion in the space provided)

Biology	Chemistry	Physics

7. Do you think practicals help you understand the subject better? (Tick  the appropriate box)

Biology	Chemistry	Physics
Yes, help in understanding <input type="checkbox"/>	Yes, help in understanding <input type="checkbox"/>	Yes, help in understanding <input type="checkbox"/>
No, confuse me <input type="checkbox"/>	No, confuse me <input type="checkbox"/>	No, confuse me <input type="checkbox"/>
Do not effect learning the subject <input type="checkbox"/>	Do not effect learning the subject <input type="checkbox"/>	Do not effect learning the subject <input type="checkbox"/>

8. Which order would allow you to learn better? Covering Theory and then doing the Practical (Theory-Practical) or doing the Practical then covering the Theory (Practical-Theory)? (Tick  the appropriate box)

Biology	Chemistry	Physics
Theory-Practical <input type="checkbox"/>	Theory-Practical <input type="checkbox"/>	Theory-Practical <input type="checkbox"/>
Practical-Theory <input type="checkbox"/>	Practical-Theory <input type="checkbox"/>	Practical-Theory <input type="checkbox"/>

9. Which experiment do you remember the most? (Write your opinion in the space provided)

Biology	Chemistry	Physics

10. Using your answer to question 9. Give a reason for your choice. (Write your opinion in the space provided)

Biology	Chemistry	Physics

11. When you are doing an experiment, do you understand the aim of the experiment (why you are doing it)? (*Tick  the appropriate box*)

Biology	Chemistry	Physics
Always <input type="checkbox"/>	Always <input type="checkbox"/>	Always <input type="checkbox"/>
Often <input type="checkbox"/>	Often <input type="checkbox"/>	Often <input type="checkbox"/>
Sometimes <input type="checkbox"/>	Sometimes <input type="checkbox"/>	Sometimes <input type="checkbox"/>
Hardly ever <input type="checkbox"/>	Hardly ever <input type="checkbox"/>	Hardly ever <input type="checkbox"/>
Never <input type="checkbox"/>	Never <input type="checkbox"/>	Never <input type="checkbox"/>

12. Do you understand what's happening during the experiment? (*Tick  the appropriate box*)

Biology	Chemistry	Physics
Always <input type="checkbox"/>	Always <input type="checkbox"/>	Always <input type="checkbox"/>
Often <input type="checkbox"/>	Often <input type="checkbox"/>	Often <input type="checkbox"/>
Sometimes <input type="checkbox"/>	Sometimes <input type="checkbox"/>	Sometimes <input type="checkbox"/>
Hardly ever <input type="checkbox"/>	Hardly ever <input type="checkbox"/>	Hardly ever <input type="checkbox"/>
Never <input type="checkbox"/>	Never <input type="checkbox"/>	Never <input type="checkbox"/>

13. What sort of instructions are you given to follow during an experiment? (*Tick  the appropriate box*)

Biology	Chemistry	Physics
Handouts <input type="checkbox"/>	Handouts <input type="checkbox"/>	Handouts <input type="checkbox"/>
Practical cards <input type="checkbox"/>	Practical cards <input type="checkbox"/>	Practical cards <input type="checkbox"/>
Instructions said aloud <input type="checkbox"/>	Instructions said aloud <input type="checkbox"/>	Instructions said aloud <input type="checkbox"/>
Book <input type="checkbox"/>	Book <input type="checkbox"/>	Book <input type="checkbox"/>
Points on the board <input type="checkbox"/>	Points on the board <input type="checkbox"/>	Points on the board <input type="checkbox"/>
Other .....	Other .....	Other .....
.....	.....	.....

14. Do you understand the instructions given? (*Tick  the appropriate box*)

Biology	Chemistry	Physics
Always <input type="checkbox"/>	Always <input type="checkbox"/>	Always <input type="checkbox"/>
Often <input type="checkbox"/>	Often <input type="checkbox"/>	Often <input type="checkbox"/>
Sometimes <input type="checkbox"/>	Sometimes <input type="checkbox"/>	Sometimes <input type="checkbox"/>
Hardly ever <input type="checkbox"/>	Hardly ever <input type="checkbox"/>	Hardly ever <input type="checkbox"/>
Never <input type="checkbox"/>	Never <input type="checkbox"/>	Never <input type="checkbox"/>

15. What can be done to help you understand instructions better? (*Write your opinion in the space provided*)

Biology	Chemistry	Physics

16. Would you consider the tasks given during the practical difficult? (*Tick  the appropriate box*)

Biology	Chemistry	Physics
Always <input type="checkbox"/>	Always <input type="checkbox"/>	Always <input type="checkbox"/>
Often <input type="checkbox"/>	Often <input type="checkbox"/>	Often <input type="checkbox"/>
Sometimes <input type="checkbox"/>	Sometimes <input type="checkbox"/>	Sometimes <input type="checkbox"/>
Hardly ever <input type="checkbox"/>	Hardly ever <input type="checkbox"/>	Hardly ever <input type="checkbox"/>
Never <input type="checkbox"/>	Never <input type="checkbox"/>	Never <input type="checkbox"/>

17. Has the difficulty of practical work changed? (*Tick  the appropriate box*)

Biology	Chemistry	Physics
Yes <input type="checkbox"/>	Yes <input type="checkbox"/>	Yes <input type="checkbox"/>
No <input type="checkbox"/>	No <input type="checkbox"/>	No <input type="checkbox"/>

18. If yes how? (*Tick  the appropriate box*)

Biology	Chemistry	Physics
More difficult <input type="checkbox"/>	More difficult <input type="checkbox"/>	More difficult <input type="checkbox"/>
Less difficult <input type="checkbox"/>	Less difficult <input type="checkbox"/>	Less difficult <input type="checkbox"/>
Remain the same <input type="checkbox"/>	Remain the same <input type="checkbox"/>	Remain the same <input type="checkbox"/>

19. Does writing reports help you understand the practical work better? (*Tick  the appropriate box*)

Biology	Chemistry	Physics
Yes <input type="checkbox"/>	Yes <input type="checkbox"/>	Yes <input type="checkbox"/>
No <input type="checkbox"/>	No <input type="checkbox"/>	No <input type="checkbox"/>

20. Which part of the report is the most important? (*Tick  the appropriate box*)

Biology	Chemistry	Physics
Aim <input type="checkbox"/>	Aim <input type="checkbox"/>	Aim <input type="checkbox"/>
Apparatus <input type="checkbox"/>	Apparatus <input type="checkbox"/>	Apparatus <input type="checkbox"/>
Method <input type="checkbox"/>	Method <input type="checkbox"/>	Method <input type="checkbox"/>
Result <input type="checkbox"/>	Result <input type="checkbox"/>	Result <input type="checkbox"/>
Precautions <input type="checkbox"/>	Precautions <input type="checkbox"/>	Precautions <input type="checkbox"/>
Sources of Error <input type="checkbox"/>	Sources of Error <input type="checkbox"/>	Sources of Error <input type="checkbox"/>
Conclusion <input type="checkbox"/>	Conclusion <input type="checkbox"/>	Conclusion <input type="checkbox"/>
Discussion <input type="checkbox"/>	Discussion <input type="checkbox"/>	Discussion <input type="checkbox"/>
All the same <input type="checkbox"/>	All the same <input type="checkbox"/>	All the same <input type="checkbox"/>

21. Which part is the least important? (*Tick  the appropriate box*)

Biology	Chemistry	Physics
Aim <input type="checkbox"/>	Aim <input type="checkbox"/>	Aim <input type="checkbox"/>
Apparatus <input type="checkbox"/>	Apparatus <input type="checkbox"/>	Apparatus <input type="checkbox"/>
Method <input type="checkbox"/>	Method <input type="checkbox"/>	Method <input type="checkbox"/>
Result <input type="checkbox"/>	Result <input type="checkbox"/>	Result <input type="checkbox"/>
Precautions <input type="checkbox"/>	Precautions <input type="checkbox"/>	Precautions <input type="checkbox"/>
Sources of Error <input type="checkbox"/>	Sources of Error <input type="checkbox"/>	Sources of Error <input type="checkbox"/>
Conclusion <input type="checkbox"/>	Conclusion <input type="checkbox"/>	Conclusion <input type="checkbox"/>
Discussion <input type="checkbox"/>	Discussion <input type="checkbox"/>	Discussion <input type="checkbox"/>
All the same <input type="checkbox"/>	All the same <input type="checkbox"/>	All the same <input type="checkbox"/>

22. How do you think marks should be given? (*Tick  the appropriate box*)

Biology	Chemistry	Physics
Each part the same amount of marks? <input type="checkbox"/>	Each part the same amount of marks? <input type="checkbox"/>	Each part the same amount of marks? <input type="checkbox"/>
More marks to certain parts? <input type="checkbox"/>	More marks to certain parts? <input type="checkbox"/>	More marks to certain parts? <input type="checkbox"/>

23. Explain your answer to the question above. (*Write your opinion in the space provided*)

Biology	Chemistry	Physics

24. Do you think that marks should be given for the handling of apparatus during an experiment? (*Tick  the appropriate box*)

Biology	Chemistry	Physics
Yes <input type="checkbox"/>	Yes <input type="checkbox"/>	Yes <input type="checkbox"/>
No <input type="checkbox"/>	No <input type="checkbox"/>	No <input type="checkbox"/>

25. What are the things that you like about practical work? (*Write your opinion in the space provided*)

Biology	Chemistry	Physics

26. What are the things that you don't like about practical work? (*Write your opinion in the space provided*)

Biology	Chemistry	Physics

27. Do you feel like a real scientist when doing experiments? (*Tick  the appropriate box*)

Biology	Chemistry	Physics
Yes <input type="checkbox"/>	Yes <input type="checkbox"/>	Yes <input type="checkbox"/>
No <input type="checkbox"/>	No <input type="checkbox"/>	No <input type="checkbox"/>

28. If yes why do you feel like a real scientist when doing the experiment? (*Write your opinion in the space provided*)

Biology	Chemistry	Physics

29. Should the experiment be carried out individually, in pairs, in groups? (*Tick  the appropriate box*)

Biology	Chemistry	Physics
Individually <input type="checkbox"/>	Individually <input type="checkbox"/>	Individually <input type="checkbox"/>
Pairs <input type="checkbox"/>	Pairs <input type="checkbox"/>	Pairs <input type="checkbox"/>
Groups <input type="checkbox"/>	Groups <input type="checkbox"/>	Groups <input type="checkbox"/>

30. Explain your answer to question 29. (*Write your opinion in the space provided*)

Biology	Chemistry	Physics

31. How can practical work be improved? (*Write your opinion in the space provided*)

Biology	Chemistry	Physics

32. Is there anything else that you would like to add about practical work?

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Thanks for your co-operation.

**Appendix 3**  
Questionnaires

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**QUESTIONNAIRE ABOUT EXPERIMENTAL WORK**

This questionnaire is about experimental work. From the results I hope to find ways in which they can be improved. Kindly fill in this questionnaire as accurately as possible. You need not write your name. Thank you for your help.

**Personal Information** (*Tick  the appropriate box*)

1.  Boy  Girl
2.  Grade 8
3. Subject studied  
 General Science

**General Questions**

4. How many experiment sessions did you have between October and December? (*Tick  the appropriate box*)

- 1 – 3
- 4 – 5
- More than 5

5. With reference to question 4, do you consider this amount to be enough? (*Tick  the appropriate box*)

- Too little
- Enough
- Too many

6. Why do you think experiments are done? (*Write your opinion in the space provided*)

.....  
.....

7. Do you think experiments help you understand the subject better? (*Tick  the appropriate box*)

- Yes, they help me
- No, they don't help me
- Do not affect learning of the subject

8. Which order do you think would allow you to learn better: Covering Theory and then doing the Experiment (Theory - Experiment) or doing the Experiment then covering the Theory (Experiment - Theory)? (*Tick  the appropriate box*)

- Theory - Experiment
- Experiment - Theory

9. Which experiment do you remember the most? (*Write your opinion in the space provided*)

.....

10. With reference to question 9, give a reason for your choice. (*Write your opinion in the space provided*)

.....  
 .....

11. Do you understand the aim when you are doing an experiment (why you are doing it)? (*Tick  the appropriate box*)

- Always
- Often
- Sometimes
- Rarely
- Never

12. Do you understand what's happening during the experiment? (*Tick  the appropriate box*)

- Always
- Often
- Sometimes
- Rarely
- Never

13. What sort of instructions are you given to follow during an experiment? (*Tick  the appropriate box*)

- Handouts
- Experiment cards
- Oral instructions (instructions said aloud)
- Book
- Points on the board
- Other .....

14. Do you understand the instructions given? (*Tick  the appropriate box*)

- Always
- Often
- Sometimes
- Rarely
- Never

15. What can be done to help you understand instructions better. (*Write your opinion in the space provided*)

.....  
 .....

16. Do you ever have experiments where you design the experiment yourself without the help of instructions? (*Tick  the appropriate box*)

- Yes
- No

17. How can designing the experiment yourself affect the learning of the subject? (*Write your opinion in the space provided*)

.....  
 .....

18. Which type of experimental work would you prefer? (*Tick  the appropriate box*)

- Designing your own experiment
- Follow a given set of instructions
- Teacher demonstrations
- Other .....

19. Give a reason for your answer to question 18. (*Write your opinion in the space provided*)

.....  
 .....

20. Are the tasks given during your experiments difficult? (*Tick  the appropriate box*)

- Always
- Often
- Sometimes
- Rarely
- Never

21. Has the difficulty of experiment work changed over the years? (*Tick  the appropriate box*)

- Yes
- No

22. If yes how? (*Tick  the appropriate box*)

- More difficult
- Less difficult

23. What are the factors that make a 'good' experiment? (*Write your opinion in the space provided*)

.....  
 .....

24. Do you feel that you will perform better in exams because you did experiment work? (*Tick  the appropriate box*)

- Yes
- No

25. Give a reason for your answer to question 24. (*Write your opinion in the space provided*)

.....  
.....

26. Does writing reports help you understand the experiment better? (*Tick  the appropriate box*)

- Yes
- No

27. What sort of help are you given to write the report? (*Tick  the appropriate box*)

- Handouts
- Teacher dictates
- Copying from board
- Textbook
- Work in a group
- None
- Other .....

28. In the report what sort of results do you include? (*Tick  the appropriate box*)

- Results *you* obtained from the experiment
- Your results which have been corrected/modified by the teacher
- Expected results - what was supposed to happen

29. Which part of the report do you think is the most important? (*Tick  the appropriate box*)

- Aim
- Apparatus
- Method
- Result
- All the same

30. Which part of the report do you think is the least important? (*Tick  the appropriate box*)

- Aim
- Apparatus
- Method
- Result
- All the same

31. On average how many marks do you usually obtain for your report? (*Tick  the appropriate box*)

- 8 – 10
- 5 – 7
- 4 or less

32. Should marks be given for reports? (*Tick  the appropriate box*)

- Yes
- No

33. Give a reason for your answer to question 32. (*Tick  the appropriate box*)

.....  
 .....

34. Should each part of the report be equally important when calculating the final mark? (*Tick  the appropriate box*)

- Each part equally important
- Some parts more important than others

35. Explain your answer to question 34. Give examples. (*Write your opinion in the space provided*)

.....  
 .....






36. Do you think that marks should be given for the actual experiment besides the report? (*Tick  the appropriate box*)

- Yes
- No

37. Should the average marks for reports be part of the annual examination mark? (*Tick  the appropriate box*)

- Yes
- No

38. Do you enjoy experiments? (*Tick  the appropriate box*)

-  No
-  A little
-  Indifferent
-  Quite
-  A lot

39. Give a reason for your answer to question 38. (*Write your opinion in the space provided*)

.....  
 .....

40. What are the things that you like about experiments? (*Write your opinion in the space provided*)

.....  
 .....

41. Which experiments did you prefer? *(Tick  the appropriate box)*

- Those of Cells
- Those of Separating techniques
- Those of Electricity
- No preference

42. What are the things that you don't like about experiments? *(Write your opinion in the space provided)*

.....

.....

43. Do you feel like a real scientist when doing experiments? *(Tick  the appropriate box)*

- Yes
- No

44. Give a reason for your answer to question 43. *(Write your opinion in the space provided)*

.....

.....

45. Should experiments be carried out individually, in pairs or in groups? *(Tick  the appropriate box)*

- Individually
- Pairs
- Groups

46. Explain your answer to question 45. *(Write your opinion in the space provided)*

.....

.....

47. How can experiments be improved? *(Write your opinion in the space provided)*

.....


.....

48. Is there anything else that you would like to add about experiment work?

.....

.....

.....

Thanks for your co-operation 

**QUESTIONNAIRE ABOUT EXPERIMENTAL WORK**

This questionnaire is about experimental work. From the results I hope to find ways in which they can be improved. Kindly fill in this questionnaire as accurately as possible. You need not write your name. Thank you for your help.

**Personal Information** (*Tick  the appropriate box*)

1.  Boy  Girl
2.  Grade 9
3. Subject studied  
 General Science

**General Questions**

4. How many experiment sessions did you have between October and December? (*Tick  the appropriate box*)

- 1 – 3
- 4 – 5
- More than 5

5. With reference to question 4, do you consider this amount to be enough? (*Tick  the appropriate box*)

- Too little
- Enough
- Too many

6. Why do you think experiments are done? (*Write your opinion in the space provided*)

.....  
.....

7. Do you think experiments help you understand the subject better? (*Tick  the appropriate box*)

- Yes, they help me
- No, they don't help me
- Do not affect learning of the subject

8. Which order do you think would allow you to learn better: Covering Theory and then doing the Experiment (Theory - Experiment) or doing the Experiment then covering the Theory (Experiment - Theory)? (*Tick  the appropriate box*)

- Theory - Experiment
- Experiment - Theory

9. Which experiment do you remember the most? (*Write your opinion in the space provided*)

.....

10. With reference to question 9, give a reason for your choice. (*Write your opinion in the space provided*)

.....  
.....

11. Do you understand the aim when you are doing an experiment (why you are doing it)? (*Tick  the appropriate box*)

- Always
- Often
- Sometimes
- Rarely
- Never

12. Do you understand what's happening during the experiment? (*Tick  the appropriate box*)

- Always
- Often
- Sometimes
- Rarely
- Never

13. What sort of instructions are you given to follow during an experiment? (*Tick  the appropriate box*)

- Handouts
- Experiment cards
- Oral instructions (instructions said aloud)
- Book
- Points on the board
- Other .....

14. Do you understand the instructions given? (*Tick  the appropriate box*)

- Always
- Often
- Sometimes
- Rarely
- Never

15. What can be done to help you understand instructions better? (*Write your opinion in the space provided*)

.....  
.....

16. Do you ever have experiments where you design the experiment yourself without the help of instructions? (*Tick  the appropriate box*)

- Yes
- No

17. How can designing the experiment yourself affect the learning of the subject? (*Write your opinion in the space provided*)

.....  
.....

18. Which type of experimental work would you prefer? (*Tick  the appropriate box*)

- Designing your own experiment
- Follow a given set of instructions
- Teacher demonstrations

Other .....

19. Give a reason for your answer to question 18. (*Write your opinion in the space provided*)

.....  
.....

20. Are the tasks given during your experiments difficult? (*Tick  the appropriate box*)

- Always
- Often
- Sometimes
- Rarely
- Never

21. Has the difficulty of experiment work changed over the years? (*Tick  the appropriate box*)

- Yes
- No

22. If yes how? (*Tick  the appropriate box*)

- More difficult
- Less difficult

23. What are the factors that make a 'good' experiment? (*Write your opinion in the space provided*)

.....  
.....

24. Do you feel that you will perform better in exams because you did experiment work? (*Tick  the appropriate box*)

- Yes
- No

25. Give a reason for your answer to question 24. (*Write your opinion in the space provided*)

.....  
.....

26. Does writing reports help you understand the experiment better? (*Tick  the appropriate box*)

- Yes
- No

27. What sort of help are you given to write the report? (*Tick  the appropriate box*)

- Handouts
- Teacher dictates
- Copying from board
- Textbook
- Work in a group
- None
- Other .....

28. In the report what sort of results do you include? (*Tick  the appropriate box*)

- Results *you* obtained from the experiment
- Your results which have been corrected/modified by the teacher
- Expected results - what was supposed to happen

29. Which part of the report do you think is the most important? (*Tick  the appropriate box*)

- Aim
- Apparatus
- Method
- Result
- Conclusion
- All the same

30. Which part of the report do you think is the least important? (*Tick  the appropriate box*)

- Aim
- Apparatus
- Method
- Result
- Conclusion
- All the same

31. On average how many marks do you usually obtain for your report? (*Tick  the appropriate box*)

- 8 – 10
- 5 – 7
- 4 or less

32. Should marks be given for reports? (Tick  the appropriate box)

Yes

No

33. Give a reason for your answer to question 32. (Tick  the appropriate box)

.....  
.....

34. Should each part of the report be equally important when calculating the final mark? (Tick  the appropriate box)

Each part equally important

Some parts more important than others

35. Explain your answer to question 34. Give examples. (Write your opinion in the space provided)

.....  
.....

36. Do you think that marks should be given for the actual experiment besides the report? (Tick  the appropriate box)

Yes

No

37. Should the average marks for reports be part of the annual examination mark? (Tick  the appropriate box)

Yes

No

38. Do you enjoy experiments? (Tick  the appropriate box)

 No

 A little

 Indifferent

 Quite

 A lot

39. Give a reason for your answer to question 38. (Write your opinion in the space provided)

.....  
.....

40. What are the things that you like about experiments? (*Write your opinion in the space provided*)

.....  
 .....

41. Which experiments did you prefer? (*Tick  the appropriate box*)

- Those of Microbes and Disease
- Those of Atoms and Elements
- Those of Light
- No preference

42. What are the things that you don't like about experiments? (*Write your opinion in the space provided*)

.....  
 .....

43. Do you feel like a real scientist when doing experiments? (*Tick  the appropriate box*)

- Yes
- No

44. Give a reason for your answer to question 43. (*Write your opinion in the space provided*)

.....  
 .....

45. Should experiments be carried out individually, in pairs or in groups? (*Tick  the appropriate box*)

- Individually
- Pairs
- Groups

46. Explain your answer to question 45. (*Write your opinion in the space provided*)

.....  
 .....

47. How can experiments be improved? (*Write your opinion in the space provided*)

.....  
 .....

48. Is there anything else that you would like to add about experiment work?

.....  
 .....

Thanks for your co-operation



**QUESTIONNAIRE ABOUT PRACTICAL WORK**

This questionnaire is about practical work. From the results I hope to find ways in which they can be improved. Kindly fill in this questionnaire as accurately as possible. You need not write your name. Thank you for your help.

**Personal Information** (*Tick  the appropriate box*)

1.      Boy                            Girl
2.      Grade 10            Grade 11            Grade 12
3. Which subjects are you studying at school?  
 Biology                    Chemistry            Physics

**General Questions** (*Only mark subjects you study*)

4. How many practical sessions did you have between October and December? (*Tick  the appropriate box*)

Biology	Chemistry	Physics
<input type="checkbox"/> 1 – 3	<input type="checkbox"/> 1 – 3	<input type="checkbox"/> 1 – 3
<input type="checkbox"/> 4 – 5	<input type="checkbox"/> 4 – 5	<input type="checkbox"/> 4 – 5
<input type="checkbox"/> More than 5	<input type="checkbox"/> More than 5	<input type="checkbox"/> More than 5

5. With reference to question 4, do you consider this amount to be enough? (*Tick  the appropriate box*)

Biology	Chemistry	Physics
<input type="checkbox"/> Too little	<input type="checkbox"/> Too little	<input type="checkbox"/> Too little
<input type="checkbox"/> Enough	<input type="checkbox"/> Enough	<input type="checkbox"/> Enough
<input type="checkbox"/> Too many	<input type="checkbox"/> Too many	<input type="checkbox"/> Too many

6. Why do you think practicals are done? (*Write your opinion in the space provided*)

Biology	Chemistry	Physics

7. Do you think practicals help you understand the subject better? (Tick  the appropriate box)

Biology	Chemistry	Physics
<input type="checkbox"/> Yes, they help me	<input type="checkbox"/> Yes, they help me	<input type="checkbox"/> Yes, they help me
<input type="checkbox"/> No, they don't help me	<input type="checkbox"/> No, they don't help me	<input type="checkbox"/> No, they don't help me
<input type="checkbox"/> Do not affect learning of the subject	<input type="checkbox"/> Do not affect learning of the subject	<input type="checkbox"/> Do not affect learning of the subject

8. Which order do you think would allow you to learn better: Covering Theory and then doing the Practical (Theory - Practical) or doing the Practical then covering the Theory (Practical - Theory)? (Tick  the appropriate box)

Biology	Chemistry	Physics
<input type="checkbox"/> Theory - Practical	<input type="checkbox"/> Theory - Practical	<input type="checkbox"/> Theory - Practical
<input type="checkbox"/> Practical - Theory	<input type="checkbox"/> Practical - Theory	<input type="checkbox"/> Practical - Theory

9. Which practical do you remember the most? (Write your opinion in the space provided)

Biology	Chemistry	Physics

10. With reference to question 9, give a reason for your choice. (Write your opinion in the space provided)

Biology	Chemistry	Physics

11. Do you understand the aim when you are doing a practical (why you are doing it)? (Tick  the appropriate box)

Biology	Chemistry	Physics
<input type="checkbox"/> Always	<input type="checkbox"/> Always	<input type="checkbox"/> Always
<input type="checkbox"/> Often	<input type="checkbox"/> Often	<input type="checkbox"/> Often
<input type="checkbox"/> Sometimes	<input type="checkbox"/> Sometimes	<input type="checkbox"/> Sometimes
<input type="checkbox"/> Rarely	<input type="checkbox"/> Rarely	<input type="checkbox"/> Rarely
<input type="checkbox"/> Never	<input type="checkbox"/> Never	<input type="checkbox"/> Never

12. Do you understand what's happening during the practical? (Tick  the appropriate box)

Biology	Chemistry	Physics
<input type="checkbox"/> Always	<input type="checkbox"/> Always	<input type="checkbox"/> Always
<input type="checkbox"/> Often	<input type="checkbox"/> Often	<input type="checkbox"/> Often
<input type="checkbox"/> Sometimes	<input type="checkbox"/> Sometimes	<input type="checkbox"/> Sometimes
<input type="checkbox"/> Rarely	<input type="checkbox"/> Rarely	<input type="checkbox"/> Rarely
<input type="checkbox"/> Never	<input type="checkbox"/> Never	<input type="checkbox"/> Never

13. What sort of instructions are you given to follow during a practical? (Tick  the appropriate box)

Biology	Chemistry	Physics
<input type="checkbox"/> Handouts	<input type="checkbox"/> Handouts	<input type="checkbox"/> Handouts
<input type="checkbox"/> Practical cards	<input type="checkbox"/> Practical cards	<input type="checkbox"/> Practical cards
<input type="checkbox"/> Oral instructions	<input type="checkbox"/> Oral instructions	<input type="checkbox"/> Oral instructions
<input type="checkbox"/> Book	<input type="checkbox"/> Book	<input type="checkbox"/> Book
<input type="checkbox"/> Points on the board	<input type="checkbox"/> Points on the board	<input type="checkbox"/> Points on the board
Other .....	Other .....	Other .....
.....	.....	.....

14. Do you understand the instructions given? (Tick  the appropriate box)

Biology	Chemistry	Physics
<input type="checkbox"/> Always	<input type="checkbox"/> Always	<input type="checkbox"/> Always
<input type="checkbox"/> Often	<input type="checkbox"/> Often	<input type="checkbox"/> Often
<input type="checkbox"/> Sometimes	<input type="checkbox"/> Sometimes	<input type="checkbox"/> Sometimes
<input type="checkbox"/> Rarely	<input type="checkbox"/> Rarely	<input type="checkbox"/> Rarely
<input type="checkbox"/> Never	<input type="checkbox"/> Never	<input type="checkbox"/> Never

15. What can be done to help you understand instructions better? (Write your opinion in the space provided)

Biology	Chemistry	Physics

16. Do you ever have practicals where you design the experiment yourself without the help of instructions? (Tick  the appropriate box)

Biology	Chemistry	Physics
<input type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input type="checkbox"/> Yes
<input type="checkbox"/> No	<input type="checkbox"/> No	<input type="checkbox"/> No

17. How can designing the practical yourself affect the learning of the subject? (*Write your opinion in the space provided*)

Biology	Chemistry	Physics

18. Which type of practical work would you prefer? (*Tick  the appropriate box*)

Biology	Chemistry	Physics
<input type="checkbox"/> Designing your own practical	<input type="checkbox"/> Designing your own practical	<input type="checkbox"/> Designing your own practical
<input type="checkbox"/> Follow a given set of instructions	<input type="checkbox"/> Follow a given set of instructions	<input type="checkbox"/> Follow a given set of instructions
<input type="checkbox"/> Teacher demonstrations	<input type="checkbox"/> Teacher demonstrations	<input type="checkbox"/> Teacher demonstrations
Other .....	Other .....	Other .....

19. Give a reason for your answer to question 18. (*Write your opinion in the space provided*)

Biology	Chemistry	Physics

20. Are the tasks given during your practicals difficult? (*Tick  the appropriate box*)

Biology	Chemistry	Physics
<input type="checkbox"/> Always	<input type="checkbox"/> Always	<input type="checkbox"/> Always
<input type="checkbox"/> Often	<input type="checkbox"/> Often	<input type="checkbox"/> Often
<input type="checkbox"/> Sometimes	<input type="checkbox"/> Sometimes	<input type="checkbox"/> Sometimes
<input type="checkbox"/> Rarely	<input type="checkbox"/> Rarely	<input type="checkbox"/> Rarely
<input type="checkbox"/> Never	<input type="checkbox"/> Never	<input type="checkbox"/> Never

21. Has the difficulty of practical work changed over the years? (*Tick  the appropriate box*)

Biology	Chemistry	Physics
<input type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input type="checkbox"/> Yes
<input type="checkbox"/> No	<input type="checkbox"/> No	<input type="checkbox"/> No

22. If yes how? (Tick  the appropriate box)

Biology	Chemistry	Physics
<input type="checkbox"/> More difficult	<input type="checkbox"/> More difficult	<input type="checkbox"/> More difficult
<input type="checkbox"/> Less difficult	<input type="checkbox"/> Less difficult	<input type="checkbox"/> Less difficult

23. What are the factors that make a 'good' practical? (Write your opinion in the space provided)

Biology	Chemistry	Physics

24. Do you feel that you will perform better in exams because you did practical work? (Tick  the appropriate box)

Biology	Chemistry	Physics
<input type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input type="checkbox"/> Yes
<input type="checkbox"/> No	<input type="checkbox"/> No	<input type="checkbox"/> No

25. Give a reason for your answer to question 24. (Write your opinion in the space provided)

Biology	Chemistry	Physics

26. Does writing reports help you understand the practical work better? (Tick  the appropriate box)

Biology	Chemistry	Physics
<input type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input type="checkbox"/> Yes
<input type="checkbox"/> No	<input type="checkbox"/> No	<input type="checkbox"/> No

27. What sort of help are you given to write the report? (Tick  the appropriate box)

Biology	Chemistry	Physics
<input type="checkbox"/> Handouts	<input type="checkbox"/> Handouts	<input type="checkbox"/> Handouts
<input type="checkbox"/> Teacher dictates	<input type="checkbox"/> Teacher dictates	<input type="checkbox"/> Teacher dictates
<input type="checkbox"/> Copying from board	<input type="checkbox"/> Copying from board	<input type="checkbox"/> Copying from board
<input type="checkbox"/> Textbook	<input type="checkbox"/> Textbook	<input type="checkbox"/> Textbook
<input type="checkbox"/> Work in a group	<input type="checkbox"/> Work in a group	<input type="checkbox"/> Work in a group
<input type="checkbox"/> None	<input type="checkbox"/> None	<input type="checkbox"/> None
Other .....	Other .....	Other .....

28. In the report what sort of results do you include? (Tick  the appropriate box)

Biology	Chemistry	Physics
<input type="checkbox"/> Results <i>you</i> obtained from the practical	<input type="checkbox"/> Results <i>you</i> obtained from the practical	<input type="checkbox"/> Results <i>you</i> obtained from the practical
<input type="checkbox"/> Your results which have been corrected/modified by the teacher	<input type="checkbox"/> Your results which have been corrected/modified by the teacher	<input type="checkbox"/> Your results which have been corrected/modified by the teacher
<input type="checkbox"/> Expected results - what was supposed to happen	<input type="checkbox"/> Expected results - what was supposed to happen	<input type="checkbox"/> Expected results - what was supposed to happen

29. Which part of the report do you think is the most important? (Tick  the appropriate box)

Biology	Chemistry	Physics
<input type="checkbox"/> Aim	<input type="checkbox"/> Aim	<input type="checkbox"/> Aim
<input type="checkbox"/> Apparatus	<input type="checkbox"/> Apparatus	<input type="checkbox"/> Apparatus
<input type="checkbox"/> Method	<input type="checkbox"/> Method	<input type="checkbox"/> Method
<input type="checkbox"/> Result	<input type="checkbox"/> Result	<input type="checkbox"/> Result
<input type="checkbox"/> Precautions	<input type="checkbox"/> Precautions	<input type="checkbox"/> Precautions
<input type="checkbox"/> Sources of Error	<input type="checkbox"/> Sources of Error	<input type="checkbox"/> Sources of Error
<input type="checkbox"/> Conclusion	<input type="checkbox"/> Conclusion	<input type="checkbox"/> Conclusion
<input type="checkbox"/> Discussion	<input type="checkbox"/> Discussion	<input type="checkbox"/> Discussion
<input type="checkbox"/> All the same	<input type="checkbox"/> All the same	<input type="checkbox"/> All the same

30. Which part of the report do you think is the least important? (Tick  the appropriate box)

Biology	Chemistry	Physics
<input type="checkbox"/> Aim	<input type="checkbox"/> Aim	<input type="checkbox"/> Aim
<input type="checkbox"/> Apparatus	<input type="checkbox"/> Apparatus	<input type="checkbox"/> Apparatus
<input type="checkbox"/> Method	<input type="checkbox"/> Method	<input type="checkbox"/> Method
<input type="checkbox"/> Result	<input type="checkbox"/> Result	<input type="checkbox"/> Result
<input type="checkbox"/> Precautions	<input type="checkbox"/> Precautions	<input type="checkbox"/> Precautions
<input type="checkbox"/> Sources of Error	<input type="checkbox"/> Sources of Error	<input type="checkbox"/> Sources of Error
<input type="checkbox"/> Conclusion	<input type="checkbox"/> Conclusion	<input type="checkbox"/> Conclusion
<input type="checkbox"/> Discussion	<input type="checkbox"/> Discussion	<input type="checkbox"/> Discussion
<input type="checkbox"/> All the same	<input type="checkbox"/> All the same	<input type="checkbox"/> All the same

31. On average how many marks do you usually obtain for your report? (Tick  the appropriate box)

Biology	Chemistry	Physics
<input type="checkbox"/> 13 – 15	<input type="checkbox"/> 13 – 15	<input type="checkbox"/> 13 – 15
<input type="checkbox"/> 9 – 12	<input type="checkbox"/> 9 – 12	<input type="checkbox"/> 9 – 12
<input type="checkbox"/> 8 or less	<input type="checkbox"/> 8 or less	<input type="checkbox"/> 8 or less

32. Should marks be given for reports? (Tick  the appropriate box)

Biology	Chemistry	Physics
<input type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input type="checkbox"/> Yes
<input type="checkbox"/> No	<input type="checkbox"/> No	<input type="checkbox"/> No

33. Give a reason for your answer to question 32. (Tick  the appropriate box)

Biology	Chemistry	Physics

34. Should each part of the report be equally important when calculating the final mark? (Tick  the appropriate box)

Biology	Chemistry	Physics
<input type="checkbox"/> Each part equally important	<input type="checkbox"/> Each part equally important	<input type="checkbox"/> Each part equally important
<input type="checkbox"/> Some parts more important than others	<input type="checkbox"/> Some parts more important than others	<input type="checkbox"/> Some parts more important than others

35. Explain your answer to question 34. Give examples. (Write your opinion in the space provided)

Biology	Chemistry	Physics
















36. Do you think that marks should be given for the actual practical besides the report? (Tick  the appropriate box)

Biology	Chemistry	Physics
<input type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input type="checkbox"/> Yes
<input type="checkbox"/> No	<input type="checkbox"/> No	<input type="checkbox"/> No

37. Should the average marks for reports be part of the annual examination mark? (Tick  the appropriate box)

Biology	Chemistry	Physics
<input type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input type="checkbox"/> Yes
<input type="checkbox"/> No	<input type="checkbox"/> No	<input type="checkbox"/> No

38. Do you enjoy practical work? (Tick  the appropriate box)

Biology	Chemistry	Physics
<input type="checkbox"/>  No	<input type="checkbox"/>  No	<input type="checkbox"/>  No
<input type="checkbox"/>  A little	<input type="checkbox"/>  A little	<input type="checkbox"/>  A little
<input type="checkbox"/>  Indifferent	<input type="checkbox"/>  Indifferent	<input type="checkbox"/>  Indifferent
<input type="checkbox"/>  Quite	<input type="checkbox"/>  Quite	<input type="checkbox"/>  Quite
<input type="checkbox"/>  A lot	<input type="checkbox"/>  A lot	<input type="checkbox"/>  A lot

39. Give a reason for your answer to question 38. (Write your opinion in the space provided)

Biology	Chemistry	Physics

40. What are the things that you like about practical work? (Write your opinion in the space provided)

Biology	Chemistry	Physics

41. Which Science subject practicals do you prefer? (Tick  the appropriate box)

- Those of Biology
- Those of Chemistry
- Those of Physics
- No preference
- Only study one Science subject

42. Give a reason for your answer to question 41. (*Write your opinion in the space provided*)

.....

.....

.....

43. What are the things that you don't like about practical work? (*Write your opinion in the space provided*)

Biology	Chemistry	Physics

44. Do you feel like a real scientist when doing practicals? (*Tick  the appropriate box*)

Biology	Chemistry	Physics
<input type="checkbox"/> Yes	<input type="checkbox"/> Yes	<input type="checkbox"/> Yes
<input type="checkbox"/> No	<input type="checkbox"/> No	<input type="checkbox"/> No

45. Give a reason for your answer to question 44. (*Write your opinion in the space provided*)

Biology	Chemistry	Physics

46. Should the practical be carried out individually, in pairs or in groups? (*Tick  the appropriate box*)

Biology	Chemistry	Physics
<input type="checkbox"/> Individually	<input type="checkbox"/> Individually	<input type="checkbox"/> Individually
<input type="checkbox"/> Pairs	<input type="checkbox"/> Pairs	<input type="checkbox"/> Pairs
<input type="checkbox"/> Groups	<input type="checkbox"/> Groups	<input type="checkbox"/> Groups

47. Explain your answer to question 46. (*Write your opinion in the space provided*)

Biology	Chemistry	Physics

48. How can practical work be improved? (*Write your opinion in the space provided*)

Biology	Chemistry	Physics

49. Is there anything else that you would like to add about practical work?

.....  
.....  
.....

Thanks for your co-operation



## **Appendix 4**

### Teacher Interviews

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### Teacher Interview

This interview is about practical work. I shall ask questions in order to find out how you use practical work in your lessons and how they can be improved.

<b>What subject do you teach? For how many years have you been teaching?</b>	
<b>What do you think about practical work? Should we do practical work? Why?</b>	<ol style="list-style-type: none"> <li>1. What do students learn from it?</li> <li>2. What should students learn from it?</li> <li>3. Do you find practical work useful?</li> <li>4. What do you hope to achieve with the labwork?</li> </ol>
<b>Do students perform better in written exams because of their experience of practical work?</b>	
<b>What do you think about the importance given to practical work?</b>	<ol style="list-style-type: none"> <li>1. Is it given too much importance, enough, not enough?</li> </ol>
<b>How often do students carry out practical work?</b>	<ol style="list-style-type: none"> <li>1. Do you consider this to be enough?</li> <li>2. Does the difficulty of practical work change over the years?</li> </ol>
<b>Which order do you think would allow students to learn better. Covering theory and then doing the Practical (Theory-Practical) or doing the Practical then covering the Theory (Practical-Theory)?</b>	Why?
<b>Which are the factors that make a good practical?</b>	<ul style="list-style-type: none"> <li>• Clear instructions</li> <li>• Good timing</li> <li>• Resources</li> <li>• Not too difficult</li> <li>• Challenging</li> </ul>

<b>On what are the instructions based?</b>	<ul style="list-style-type: none"> <li>• On instructional goals or what the students are expected to do</li> </ul>
<b>Are practicals carried out individually, in pairs or in groups? Why? Does the laboratory work have any social goals?</b>	<ul style="list-style-type: none"> <li>• Friendship</li> <li>• Working in groups</li> <li>• Sharing</li> <li>• Communication</li> </ul> <ol style="list-style-type: none"> <li>1. How do you value these goals?</li> <li>2. How do these goals fit in with the practical work required?</li> </ol>
<b>Are reports written for all the practicals done?</b>	<ol style="list-style-type: none"> <li>1. Is there a specific format which you ask students to follow when writing practical work?</li> <li>2. Are students ever asked to pool results? Why?</li> <li>3. Does the lab report mark cover the skills used while doing the practical?</li> </ol>
<b>How does writing reports help students?</b>	<ol style="list-style-type: none"> <li>1. <b>Does writing reports help students understand the practical work better?</b></li> <li>2. What sort of help is given to write the report?</li> <li>3. What sort of results are included?</li> <li>4. Are all parts of the report equally important?</li> <li>5. Should marks be given for the reports?</li> <li>6. Should marks be given for the actual practical besides the report?</li> <li>7. Can students redo the report if they didn't do so well in it?</li> </ol>
<b>To what extent is practical work used for teaching?</b>	

<p><b>Are students ever asked to pose the question to be investigated, formulate a hypothesis to test, or plan the experimental procedure?</b></p>	<ol style="list-style-type: none"> <li>1. How can designing the practical themselves affect the learning of the subject?</li> </ol>
<p><b>Do you give students experiments which teach skills?</b></p>	<ol style="list-style-type: none"> <li>1. How would you carry out this activity to meet this purpose?</li> <li>2. What should the students learn by the end of such an experiment which they didn't know before?</li> <li>3. Are there any other strategies which you use to teach these ideas, and why?</li> <li>4. Is one way better than the other?</li> </ol>
<p><b>Do you carry out demonstrations?</b></p>	<ol style="list-style-type: none"> <li>1. What would be the purpose of doing a demonstration?</li> <li>2. How would you carry out this activity to meet this purpose?</li> <li>3. What should the students learn by the end of such an experiment which they didn't know before?</li> <li>4. Are there any other strategies which you use to teach these ideas, and why?</li> <li>5. Is one way better than the other?</li> </ol>
<p><b>Do you give students experiments in order to illustrate a phenomenon?</b></p>	<ol style="list-style-type: none"> <li>1. How would you carry out this activity to meet this purpose?</li> <li>2. What should the students learn by the end of such an experiment which they didn't know before?</li> <li>3. Are there any other strategies which you use to teach these ideas, and why?</li> <li>4. Is one way better than the other?</li> </ol>

<p><b>Do you give students investigations?</b></p>	<ol style="list-style-type: none"> <li>1. What would be the purpose of an investigation?</li> <li>2. How would you carry out this activity to meet this purpose?</li> <li>3. What should the students learn by the end of such an experiment which they didn't know before?</li> <li>4. Are there any other strategies which you use to teach these ideas, and why?</li> <li>5. Is one way better than the other?</li> </ol>
<p><b>Which of the four types is most important? Why?</b></p>	
<p><b>Are informal discussions allowed during laboratory work? Why?</b></p>	
<p><b>How is labwork assessed?</b></p>	<ol style="list-style-type: none"> <li>1. Which skills are assessed during laboratory exercises?</li> </ol>
<p><b>What are your views about assessment of practical work?</b></p>	<ol style="list-style-type: none"> <li>1. The fact that Matsec imposes that practicals should be done how does it affect you?</li> <li>2. Does the present form of assessment restrict you in any way?</li> <li>3. Are the assessment criteria in the Matsec syllabus applicable to labwork?</li> </ol>
<p><b>Should the average marks for reports be part of the annual examination mark?</b></p>	
<p><b>Are school practicals related to the practical science carried out by professionals as part of their job?</b></p>	<ol style="list-style-type: none"> <li>1. If so, do these compare with the purpose of school practical work?</li> </ol>

<b>How can practical work be improved?</b>	<ul style="list-style-type: none"> <li>• Frequency</li> <li>• Duration</li> <li>• Type of experiment</li> <li>• Student involvement</li> <li>• Reports</li> <li>• Instruction</li> <li>• Assessment</li> <li>• Safety</li> </ul>
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### Examples of practicals

#### General Science

Types	
<b>Skill</b>	Microscopy
<b>Demonstration</b>	Test for oxygen or burning magnesium in air
<b>Illustration</b>	Prisms
<b>Investigation</b>	Mysterious food (To investigate a type of food to see whether it has sugars, starch, fats and proteins)

#### Biology

Types	
<b>Skill</b>	Drawing microscopic diagrams of <i>Mucor</i>
<b>Demonstration</b>	Respiration or dissections
<b>Illustration</b>	Testing for glucose
<b>Investigation</b>	The effect of pH on the reaction between pepsin and egg-white suspension

**Chemistry**

<b>Types</b>	
<b>Skill</b>	Using separation techniques
<b>Demonstration</b>	The reaction between sodium and water
<b>Illustration</b>	Preparation of copper sulphate from copper oxide
<b>Investigation</b>	The reaction between marble chips and acid (how does the concentration of the acid affect the rate of reaction between limestone and an acid?)

**Physics**

<b>Types</b>	
<b>Skill</b>	Connecting a simple circuit
<b>Demonstration</b>	Radiation from a hot plate
<b>Illustration</b>	Refraction in a glass block
<b>Investigation</b>	Slope investigation (how speed depends on slope, by rolling a ball down a ramp)

**Appendix 5**  
Statistical Data

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5.1a

Values

Question : How many practical sessions did you have between October and December?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	0	1	1	5	2	7	11	13	24	36	23	59	53	45	98	5	3	8	19	28	47	31	31	62	50	22	72		
B	5	1	6	10	6	16	22	22	44	19	21	40	11	9	20	15	7	22	19	27	46	10	6	16	23	19	42		
C	40	35	75	31	21	52	31	23	54	13	20	33	4	0	4	71	56	127	18	24	42	3	2	5	27	17	44		

	Biology									Chemistry									Physics								
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	2	2	4	4	6	10	13	20	33	6	10	16	14	10	24	11	11	22	3	1	4	18	7	25	29	14	43
B	5	9	14	8	12	20	6	6	12	8	3	11	0	1	1	2	2	4	9	10	19	11	8	19	3	1	4
C	11	16	27	5	8	13	2	0	2	3	0	3	0	2	2	0	0	0	17	7	24	8	10	18	2	0	2

Key

A | 1 to 3

B | 4 to 5

C | More than 5

## 5.1b

## Percentages

Question : How many practical sessions did you have between October and December?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	0.0	2.7	1.2	10.9	6.9	9.3	17.2	22.4	19.7	52.9	35.9	44.7	77.9	83.3	80.3	5.5	4.5	5.1	33.9	35.4	34.8	70.5	79.5	74.7	50.0	37.9	45.6		
B	11.1	2.7	7.3	21.7	20.7	21.3	34.4	37.9	36.1	27.9	32.8	30.3	16.2	16.7	16.4	16.5	10.6	14.0	33.9	34.2	34.1	22.7	15.4	19.3	23.0	32.8	26.6		
C	88.9	94.6	91.5	67.4	72.4	69.3	48.4	39.7	44.3	19.1	31.3	25.0	5.9	0.0	3.3	78.0	84.8	80.9	32.1	30.4	31.1	6.8	5.1	6.0	27.0	29.3	27.8		

	Biology									Chemistry									Physics								
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	11.1	7.4	8.9	23.5	23.1	23.3	61.9	76.9	70.2	35.3	76.9	53.3	100.0	76.9	88.9	84.6	84.6	84.6	10.3	5.6	8.5	48.6	28.0	40.3	85.3	93.3	87.8
B	27.8	33.3	31.1	47.1	46.2	46.5	28.6	23.1	25.5	27.1	23.1	36.7	0.0	7.7	3.7	15.4	15.4	15.4	31.0	55.6	40.4	29.7	32.0	30.6	8.8	6.7	8.2
C	61.1	59.3	60.0	29.4	30.8	30.2	9.5	0.0	4.3	17.6	0.0	10.0	0.0	15.4	7.4	0.0	0.0	0.0	58.6	38.9	51.1	21.6	40.0	29.0	5.9	0.0	4.1

## Key

A	1 to 3	B	4 to 5	C	More than 5
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5.2a

Values

Question : With reference to question 5.1, do you consider this amount to be enough?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	12	5	17	18	3	21	9	5	14	7	13	20	3	0	3	30	8	38	5	4	9	3	7	10	11	7	18			
B	30	32	62	27	22	49	40	42	82	54	45	99	60	50	110	57	54	111	40	63	103	38	29	67	76	45	121			
C	2	0	2	1	4	5	16	11	27	7	8	15	4	4	8	3	4	7	11	13	24	3	3	6	13	7	20			

	Biology						Chemistry						Physics																	
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	3	2	5	2	2	4	0	0	0	1	2	3	1	5	6	1	0	1	5	1	6	4	6	10	2	0	2			
B	10	19	29	11	21	32	19	23	42	14	9	23	13	8	21	11	12	23	16	14	30	30	16	46	30	15	45			
C	5	6	11	4	4	8	2	3	5	2	2	4	0	0	0	1	1	2	9	3	12	3	4	7	1	0	1			

Key

A Too little

B Enough

C Too many

5.2b

Percentages

Question : With reference to question 5.1, do you consider this amount to be enough?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	27.3	13.5	21.0	39.1	10.3	28.0	13.8	8.6	11.4	10.3	19.7	14.9	4.5	0.0	2.5	33.3	12.1	24.4	8.9	5.0	6.6	6.8	17.9	12.0	11.0	11.9	11.3		
B	68.2	86.5	76.5	58.7	75.9	65.3	61.5	72.4	66.7	79.4	68.2	73.9	89.6	92.6	90.9	63.3	81.8	71.2	71.4	78.8	75.7	86.4	74.4	80.7	76.0	76.3	76.1		
C	4.5	0.0	2.5	2.2	13.8	6.7	24.6	19.0	22.0	10.3	12.1	11.2	6.0	7.4	6.6	3.3	6.1	4.5	19.6	16.3	17.6	6.8	7.7	7.2	13.0	11.9	12.6		

	Biology									Chemistry									Physics										
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	16.7	7.4	11.1	11.8	7.4	9.1	0.0	0.0	0.0	5.9	15.4	10.0	7.1	38.5	22.2	7.7	0.0	3.8	16.7	5.6	12.5	10.8	23.1	15.9	6.1	0.0	4.2		
B	55.6	70.4	64.4	64.7	77.8	72.7	90.5	88.5	89.4	82.4	69.2	76.7	92.9	61.5	77.8	84.6	92.3	88.5	53.3	77.8	62.5	81.1	61.5	73.0	90.9	100.0	93.8		
C	27.8	22.2	24.4	23.5	14.8	18.2	9.5	11.5	10.6	11.8	15.4	13.3	0.0	0.0	0.0	7.7	7.7	7.7	30.0	16.7	25.0	8.1	15.4	11.1	3.0	0.0	2.1		

Key

A	Too little	B	Enough	C	Too many
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5.3a

Values

Question : Do you think practicals help you understand the subject better?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	44	35	79	41	27	68	56	54	110	63	60	123	55	45	100	85	62	147	47	70	117	40	34	74	87	55	142		
B	0	1	1	1	0	1	3	1	4	1	2	3	6	0	6	1	1	2	4	1	5	0	1	1	6	1	7		
C	1	0	1	5	2	7	5	3	8	4	4	8	7	8	15	6	2	8	5	8	13	4	4	8	7	3	10		

	Biology									Chemistry									Physics										
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	15	26	41	16	24	40	16	20	36	16	11	27	13	12	25	11	11	22	25	17	42	34	24	58	28	14	42		
B	1	0	1	0	1	1	3	0	3	0	0	0	0	1	1	0	0	0	2	1	3	1	0	1	3	0	3		
C	2	1	3	1	2	3	2	5	7	1	2	3	1	0	1	2	2	4	2	0	2	2	2	4	3	1	4		

Key

A Yes, they help me

B No, they don't help me

C Do not affect learning of the subject

5.3b

Percentages

Question : Do you think practicals help you understand the subject better?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	97.8	97.2	97.5	87.2	93.1	89.5	87.5	93.1	90.2	92.6	90.9	91.8	80.9	84.9	82.6	92.4	95.4	93.6	83.9	88.6	86.7	90.9	87.2	89.2	87.0	93.2	89.3		
B	0.0	2.8	1.2	2.1	0.0	1.3	4.7	1.7	3.3	1.5	3.0	2.2	8.8	0.0	5.0	1.1	1.5	1.3	7.1	1.3	3.7	0.0	2.6	1.2	6.0	1.7	4.4		
C	2.2	0.0	1.2	10.6	6.9	9.2	7.8	5.2	6.6	5.9	6.1	6.0	10.3	15.1	12.4	6.5	3.1	5.1	8.9	10.1	9.6	9.1	10.3	9.6	7.0	5.1	6.3		

	Biology									Chemistry									Physics								
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	83.3	96.3	91.1	94.1	88.9	90.9	76.2	80.0	78.3	94.1	84.6	90.0	92.9	92.3	92.6	84.6	84.6	84.6	86.2	94.4	89.4	91.9	92.3	92.1	82.4	93.3	85.7
B	5.6	0.0	2.2	0.0	3.7	2.3	14.3	0.0	6.5	0.0	0.0	0.0	0.0	7.7	3.7	0.0	0.0	0.0	6.9	5.6	6.4	2.7	0.0	1.6	8.8	0.0	6.1
C	11.1	3.7	6.7	5.9	7.4	6.8	9.5	20.0	15.2	5.9	15.4	10.0	7.1	0.0	3.7	15.4	15.4	15.4	6.9	0.0	4.3	5.4	7.7	6.3	8.8	6.7	8.2

Key

<b>A</b>	Yes, they help me	<b>B</b>	No, they don't help me	<b>C</b>	Do not affect learning of the subject
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5.4a

Values

Question : Which order do you think would allow you to learn better: Covering Theory and then doing the Practical (Theory - Practical) or doing the Practical then covering the Theory (Practical - Theory)?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	33	31	64	22	20	42	53	45	98	56	61	117	51	44	95	55	51	106	47	70	117	36	32	68	77	48	125		
B	12	6	18	23	8	31	10	13	23	12	5	17	17	10	27	35	14	49	9	10	19	7	7	14	23	11	34		

	Biology									Chemistry									Physics										
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	16	21	37	13	27	40	18	22	40	15	11	26	12	11	23	9	10	19	22	13	35	31	23	54	24	12	36		
B	2	6	8	4	0	4	3	4	7	1	2	3	2	2	4	4	3	7	7	5	12	6	3	9	10	3	13		

Key

A Theory - Practical

B Practical - Theory

5.4b

Percentages

Question : Which order do you think would allow you to learn better: Covering Theory and then doing the Practical (Theory - Practical) or doing the Practical then covering the Theory (Practical - Theory)?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	73.3	83.8	78.0	48.9	71.4	57.5	84.1	77.6	81.0	82.4	92.4	87.3	75.0	81.5	77.9	61.1	78.5	68.4	83.9	87.5	86.0	83.7	82.1	82.9	77.0	81.4	78.6		
B	26.7	16.2	22.0	51.1	28.6	42.5	15.9	22.4	19.0	17.6	7.6	12.7	25.0	18.5	22.1	38.9	21.5	31.6	16.1	12.5	14.0	16.3	17.9	17.1	23.0	18.6	21.4		

	Biology									Chemistry									Physics								
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	88.9	77.8	82.2	76.5	100.0	90.9	85.7	84.6	85.1	93.8	84.6	89.7	85.7	84.6	85.2	69.2	76.9	73.1	75.9	72.2	74.5	83.8	88.5	85.7	70.6	80.0	73.5
B	11.1	22.2	17.8	23.5	0.0	9.1	14.3	15.4	14.9	6.3	15.4	10.3	14.3	15.4	14.8	30.8	23.1	26.9	24.1	27.8	25.5	16.2	11.5	14.3	29.4	20.0	26.5

Key

A Theory - Practical

B Practical - Theory

5.5a

Values

Question : Do you understand the aim when you are doing a practical (why you are doing it)?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	31	11	42	15	13	28	30	14	44	32	19	51	30	24	54	46	24	70	27	20	47	20	13	33	45	24	69		
B	21	17	38	20	10	30	27	28	55	26	29	55	19	19	38	41	27	68	20	38	58	12	14	26	40	24	64		
C	11	8	19	9	4	13	4	12	16	8	15	23	14	8	22	20	12	32	8	18	26	8	7	15	10	10	20		
D	0	1	1	0	2	2	1	2	3	1	3	4	2	1	3	0	3	3	0	2	2	2	3	5	2	1	3		
E	0	0	0	3	0	3	2	2	4	1	0	1	2	2	4	3	0	3	1	2	3	2	2	4	2	0	2		

	Biology									Chemistry									Physics										
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	10	5	15	9	6	15	8	9	17	7	3	10	8	8	16	5	2	7	13	6	19	15	5	20	17	13	30		
B	7	17	24	5	11	16	8	10	18	6	3	9	4	2	6	2	9	11	14	8	22	17	16	33	9	0	9		
C	1	4	5	3	8	11	4	6	10	2	4	6	1	2	3	5	1	6	1	4	5	4	5	9	5	1	6		
D	0	0	0	0	2	2	0	0	0	1	2	3	0	1	1	1	0	1	0	0	0	1	0	1	1	1	2		
E	0	1	1	0	0	0	1	1	2	1	1	2	1	0	1	0	1	1	1	0	1	0	0	0	1	0	1		

Key

A Always  
D Rarely

B Often  
E Never

C Sometimes

5.5b

Percentages

Question : Do you understand the aim when you are doing a practical (why you are doing it)?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	49.2	29.7	42.0	31.9	44.8	36.8	46.9	24.1	36.1	47.1	28.8	38.1	44.8	44.4	44.6	41.8	36.4	39.8	48.2	25.0	34.6	45.5	33.3	39.8	45.5	40.7	43.7		
B	33.3	45.9	38.0	42.6	34.5	39.5	42.2	48.3	45.1	38.2	43.9	41.0	28.4	35.2	31.4	37.3	40.9	38.6	35.7	47.5	42.6	27.3	35.9	31.3	40.4	40.7	40.5		
C	17.5	21.6	19.0	19.1	13.8	17.1	6.3	20.7	13.1	11.8	22.7	17.2	20.9	14.8	18.2	18.2	18.2	18.2	14.3	22.5	19.1	18.2	17.9	18.1	10.1	16.9	12.7		
D	0.0	2.7	1.0	0.0	6.9	2.6	1.6	3.4	2.5	1.5	4.5	3.0	3.0	1.9	2.5	0.0	4.5	1.7	0.0	2.5	1.5	4.5	7.7	6.0	2.0	1.7	1.9		
E	0.0	0.0	0.0	6.4	0.0	3.9	3.1	3.4	3.3	1.5	0.0	0.7	3.0	3.7	3.3	2.7	0.0	1.7	1.8	2.5	2.2	4.5	5.1	4.8	2.0	0.0	1.3		

	Biology									Chemistry									Physics										
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	55.6	18.5	33.3	52.9	22.2	34.1	38.1	34.6	36.2	41.2	23.1	33.3	57.1	61.5	59.3	38.5	15.4	26.9	44.8	33.3	40.4	40.5	19.2	31.7	51.5	86.7	62.5		
B	38.9	63.0	53.3	29.4	40.7	36.4	38.1	38.5	38.3	35.3	23.1	30.0	28.6	15.4	22.2	15.4	69.2	42.3	48.3	44.4	46.8	45.9	61.5	52.4	27.3	0.0	18.8		
C	5.6	14.8	11.1	17.6	29.6	25.0	19.0	23.1	21.3	11.8	30.8	20.0	7.1	15.4	11.1	38.5	7.7	23.1	3.4	22.2	10.6	10.8	19.2	14.3	15.2	6.7	12.5		
D	0.0	0.0	0.0	0.0	7.4	4.5	0.0	0.0	0.0	5.9	15.4	10.0	0.0	7.7	3.7	7.7	0.0	3.8	0.0	0.0	0.0	2.7	0.0	1.6	3.0	6.7	4.2		
E	0.0	3.7	2.2	0.0	0.0	0.0	4.8	3.8	4.3	5.9	7.7	6.7	7.1	0.0	3.7	0.0	7.7	3.8	3.4	0.0	2.1	0.0	0.0	0.0	3.0	0.0	2.1		

Key

A Always  
D RarelyB Often  
E Never

C Sometimes

5.6a

Values

Question : Do you understand what's happened during the practical?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	21	13	34	18	9	27	33	22	55	27	20	47	25	23	48	39	22	61	25	26	51	16	12	28	44	27	71		
B	21	19	40	18	16	34	22	27	49	30	29	59	26	14	40	39	35	74	21	32	53	16	14	30	41	24	65		
C	3	5	8	7	2	9	4	6	10	8	13	21	11	15	26	10	7	17	8	19	27	5	9	14	10	6	16		
D	0	0	0	1	0	1	1	2	3	1	4	5	4	3	7	1	0	1	0	3	3	5	5	10	1	1	2		
E	0	0	0	3	2	5	4	0	4	1	0	1	2	0	2	3	2	5	2	0	2	2	0	2	3	0	3		

	Biology									Chemistry									Physics										
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	9	8	17	7	7	14	9	11	20	7	3	10	7	4	11	2	5	7	17	11	28	13	9	22	14	7	21		
B	6	17	23	7	10	17	8	5	13	7	5	12	5	4	9	4	5	9	9	5	14	18	15	33	14	4	18		
C	2	2	4	3	8	11	3	9	12	0	3	3	1	3	4	4	3	7	2	1	3	4	2	6	4	3	7		
D	0	0	0	0	2	2	0	1	1	1	2	3	1	2	3	3	1	4	0	0	0	0	0	0	1	1	2		
E	1	0	1	0	0	0	1	0	1	2	0	2	0	0	0	0	0	0	1	0	1	1	0	1	1	0	1		

Key

A Always  
D Rarely

B Often  
E Never

C Sometimes

5.6b

Percentages

Question : Do you understand what's happened during the practical?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	46.7	35.1	41.5	38.3	31.0	35.5	51.6	38.6	45.5	40.3	30.3	35.3	36.8	41.8	39.0	42.4	33.3	38.6	44.6	32.5	37.5	36.4	30.0	33.3	44.4	46.6	45.2		
B	46.7	51.4	48.8	38.3	55.2	44.7	34.4	47.4	40.5	44.8	43.9	44.4	38.2	25.5	32.5	42.4	53.0	46.8	37.5	40.0	39.0	36.4	35.0	35.7	41.4	41.4	41.4		
C	6.7	13.5	9.8	14.9	6.9	11.8	6.3	10.5	8.3	11.9	19.7	15.8	16.2	27.3	21.1	10.9	10.6	10.8	14.3	23.8	19.9	11.4	22.5	16.7	10.1	10.3	10.2		
D	0.0	0.0	0.0	2.1	0.0	1.3	1.6	3.5	2.5	1.5	6.1	3.8	5.9	5.5	5.7	1.1	0.0	0.6	0.0	3.8	2.2	11.4	12.5	11.9	1.0	1.7	1.3		
E	0.0	0.0	0.0	6.4	6.9	6.6	6.3	0.0	3.3	1.5	0.0	0.8	2.9	0.0	1.6	3.3	3.0	3.2	3.6	0.0	1.5	4.5	0.0	2.4	3.0	0.0	1.9		

	Biology									Chemistry									Physics										
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	50.0	29.6	37.8	41.2	25.9	31.8	42.9	42.3	42.6	41.2	23.1	33.3	50.0	30.8	40.7	15.4	35.7	25.9	58.6	64.7	60.9	36.1	34.6	35.5	41.2	46.7	42.9		
B	33.3	63.0	51.1	41.2	37.0	38.6	38.1	19.2	27.7	41.2	38.5	40.0	35.7	30.8	33.3	30.8	35.7	33.3	31.0	29.4	30.4	50.0	57.7	53.2	41.2	26.7	36.7		
C	11.1	7.4	8.9	17.6	29.6	25.0	14.3	34.6	25.5	0.0	23.1	10.0	7.1	23.1	14.8	30.8	21.4	25.9	6.9	5.9	6.5	11.1	7.7	9.7	11.8	20.0	14.3		
D	0.0	0.0	0.0	0.0	7.4	4.5	0.0	3.8	2.1	5.9	15.4	10.0	7.1	15.4	11.1	23.1	7.1	14.8	0.0	0.0	0.0	0.0	0.0	0.0	2.9	6.7	4.1		
E	5.6	0.0	2.2	0.0	0.0	0.0	4.8	0.0	2.1	11.8	0.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0	2.2	2.8	0.0	1.6	2.9	0.0	2.0		

Key

A Always  
D Rarely

B Often  
E Never

C Sometimes

5.7a

Values

Question : What sort of instructions are you given to follow during a practical?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	27	22	49	25	20	45	20	22	42	35	34	69	31	28	59	52	42	94	50	69	119	4	0	4	32	15	47		
B	2	1	3	1	0	1	16	13	29	15	14	29	13	13	26	3	1	4	2	3	5	39	35	74	3	2	5		
C	14	14	28	16	9	25	42	37	79	30	40	70	33	29	62	30	23	53	27	47	74	18	18	36	60	41	101		
D	15	7	22	17	5	22	18	11	29	22	19	41	3	3	6	32	12	44	4	10	14	3	4	7	36	19	55		
E	17	8	25	10	5	15	20	11	31	17	23	40	26	22	48	27	13	40	17	33	50	15	11	26	31	12	43		
O	6	5	11	3	4	7	0	9	9	5	9	14	1	0	1	9	9	18	1	2	3	0	2	2	5	14	19		

	Biology									Chemistry									Physics										
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	15	19	34	17	25	42	18	25	43	1	0	1	2	0	2	1	0	1	4	3	7	16	9	25	12	3	15		
B	0	2	2	1	0	1	1	1	2	14	11	25	14	12	26	11	12	23	2	0	2	0	2	2	1	0	1		
C	12	18	30	8	16	24	7	13	20	7	6	13	6	8	14	5	4	9	23	13	36	16	16	32	21	12	33		
D	3	4	7	0	3	3	1	3	4	1	0	1	2	4	6	0	0	0	14	7	21	20	12	32	2	0	2		
E	7	9	16	4	12	16	6	12	18	6	1	7	6	7	13	3	3	6	7	1	8	7	4	11	17	7	24		
O	0	2	2	1	0	1	0	0	0	0	1	1	0	1	1	0	0	0	0	6	6	4	8	12	1	0	1		

Key

A	Handouts	B	Practical cards	C	Oral instructions
D	Book	E	Points on the board	O	Other

5.7b

Percentages

Question : What sort of instructions are you given to follow during a practical?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	33.3	38.6	35.5	34.7	46.5	39.1	17.2	21.4	19.2	28.2	24.5	26.2	29.0	29.5	29.2	34.0	42.0	37.2	49.5	42.1	44.9	5.1	0.0	2.7	19.2	14.6	17.4		
B	2.5	1.8	2.2	1.4	0.0	0.9	13.8	12.6	13.2	12.1	10.1	11.0	12.1	13.7	12.9	2.0	1.0	1.6	2.0	1.8	1.9	49.4	50.0	49.7	1.8	1.9	1.9		
C	17.3	24.6	20.3	22.2	20.9	21.7	36.2	35.9	36.1	24.2	28.8	26.6	30.8	30.5	30.7	19.6	23.0	20.9	26.7	28.7	27.9	22.8	25.7	24.2	35.9	39.8	37.4		
D	18.5	12.3	15.9	23.6	11.6	19.1	15.5	10.7	13.2	17.7	13.7	15.6	2.8	3.2	3.0	20.9	12.0	17.4	4.0	6.1	5.3	3.8	5.7	4.7	21.6	18.4	20.4		
E	21.0	14.0	18.1	13.9	11.6	13.0	17.2	10.7	14.2	13.7	16.5	15.2	24.3	23.2	23.8	17.6	13.0	15.8	16.8	20.1	18.9	19.0	15.7	17.4	18.6	11.7	15.9		
O	7.4	8.8	8.0	4.2	9.3	6.1	0.0	8.7	4.1	4.0	6.5	5.3	0.9	0.0	0.5	5.9	9.0	7.1	1.0	1.2	1.1	0.0	2.9	1.3	3.0	13.6	7.0		

	Biology									Chemistry									Physics										
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	40.5	35.2	37.4	54.8	44.6	48.3	54.5	46.3	49.4	3.4	0.0	2.1	6.7	0.0	3.2	5.0	0.0	2.6	8.0	10.0	8.8	25.4	17.6	21.9	22.2	13.6	19.7		
B	0.0	3.7	2.2	3.2	0.0	1.1	3.0	1.9	2.3	48.3	57.9	52.1	46.7	37.5	41.9	55.0	63.2	59.0	4.0	0.0	2.5	0.0	3.9	1.8	1.9	0.0	1.3		
C	32.4	33.3	33.0	25.8	28.6	27.6	21.2	24.1	23.0	24.1	31.6	27.1	20.0	25.0	22.6	25.0	21.1	23.1	46.0	43.3	45.0	25.4	31.4	28.1	38.9	54.5	43.4		
D	8.1	7.4	7.7	0.0	5.4	3.4	3.0	5.6	4.6	3.4	0.0	2.1	6.7	12.5	9.7	0.0	0.0	0.0	28.0	23.3	26.3	31.7	23.5	28.1	3.7	0.0	2.6		
E	18.9	16.7	17.6	12.9	21.4	18.4	18.2	22.2	20.7	20.7	5.3	14.6	20.0	21.9	21.0	15.0	15.8	15.4	14.0	3.3	10.0	11.1	7.8	9.6	31.5	31.8	31.6		
O	0.0	3.7	2.2	3.2	0.0	1.1	0.0	0.0	0.0	0.0	5.3	2.1	0.0	3.1	1.6	0.0	0.0	0.0	0.0	20.0	7.5	6.3	15.7	10.5	1.9	0.0	1.3		

Key

A	Handouts	B	Practical cards	C	Oral instructions
D	Book	E	Points on the board	O	Other

5.8a

Values

Question : Do you understand the instructions given?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	19	10	29	12	8	20	25	27	52	27	18	45	20	20	40	31	18	49	26	26	52	15	12	27	31	27	58		
B	19	19	38	18	16	34	25	23	48	28	36	64	36	21	57	37	35	72	17	41	58	22	14	36	50	25	75		
C	7	8	15	12	3	15	8	5	13	10	9	19	10	12	22	19	11	30	11	11	22	2	8	10	15	7	22		
D	0	0	0	1	2	3	2	2	4	1	3	4	1	1	2	1	2	3	0	1	1	2	5	7	2	0	2		
E	0	0	0	3	0	3	4	0	4	1	0	1	1	0	1	3	0	3	2	0	2	3	0	3	1	0	1		

	Biology									Chemistry									Physics										
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	8	14	22	10	5	15	8	7	15	6	3	9	6	4	10	3	5	8	11	10	21	11	9	20	9	8	17		
B	7	11	18	3	16	19	7	14	21	6	6	12	7	4	11	9	4	13	12	6	18	18	16	34	20	3	23		
C	2	1	3	4	5	9	5	5	10	1	2	3	0	3	3	1	3	4	5	2	7	6	1	7	4	4	8		
D	0	0	0	0	1	1	0	0	0	2	2	4	0	2	2	0	1	1	0	0	0	1	0	1	1	0	1		
E	1	0	1	0	0	0	1	0	1	2	0	2	1	0	1	0	0	0	1	0	1	0	0	0	0	0	0		

Key

A Always  
D Rarely

B Often  
E Never

C Sometimes

5.8b

Percentages

Question : Do you understand the instructions given?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	42.2	27.0	35.4	26.1	27.6	26.7	39.1	47.4	43.0	40.3	27.3	33.8	29.4	37.0	32.8	34.1	27.3	31.2	46.4	32.9	38.5	34.1	30.8	32.5	31.3	45.8	36.7		
B	42.2	51.4	46.3	39.1	55.2	45.3	39.1	40.4	39.7	41.8	54.5	48.1	52.9	38.9	46.7	40.7	53.0	45.9	30.4	51.9	43.0	50.0	35.9	43.4	50.5	42.4	47.5		
C	15.6	21.6	18.3	26.1	10.3	20.0	12.5	8.8	10.7	14.9	13.6	14.3	14.7	22.2	18.0	20.9	16.7	19.1	19.6	13.9	16.3	4.5	20.5	12.0	15.2	11.9	13.9		
D	0.0	0.0	0.0	2.2	6.9	4.0	3.1	3.5	3.3	1.5	4.5	3.0	1.5	1.9	1.6	1.1	3.0	1.9	0.0	1.3	0.7	4.5	12.8	8.4	2.0	0.0	1.3		
E	0.0	0.0	0.0	6.5	0.0	4.0	6.3	0.0	3.3	1.5	0.0	0.8	1.5	0.0	0.8	3.3	0.0	1.9	3.6	0.0	1.5	6.8	0.0	3.6	1.0	0.0	0.6		

	Biology									Chemistry									Physics										
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	44.4	53.8	50.0	58.8	18.5	34.1	38.1	26.9	31.9	35.3	23.1	30.0	42.9	30.8	37.0	23.1	38.5	30.8	37.9	55.6	44.7	30.6	34.6	32.3	26.5	53.3	34.7		
B	38.9	42.3	40.9	17.6	59.3	43.2	33.3	53.8	44.7	35.3	46.2	40.0	50.0	30.8	40.7	69.2	30.8	50.0	41.4	33.3	38.3	50.0	61.5	54.8	58.8	20.0	46.9		
C	11.1	3.8	6.8	23.5	18.5	20.5	23.8	19.2	21.3	5.9	15.4	10.0	0.0	23.1	11.1	7.7	23.1	15.4	17.2	11.1	14.9	16.7	3.8	11.3	11.8	26.7	16.3		
D	0.0	0.0	0.0	0.0	3.7	2.3	0.0	0.0	0.0	11.8	15.4	13.3	0.0	15.4	7.4	0.0	7.7	3.8	0.0	0.0	0.0	2.8	0.0	1.6	2.9	0.0	2.0		
E	5.6	0.0	2.3	0.0	0.0	0.0	4.8	0.0	2.1	11.8	0.0	6.7	7.1	0.0	3.7	0.0	0.0	0.0	3.4	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0		

Key

A Always  
D RarelyB Often  
E Never

C Sometimes

5.9a

Values

Question : Do you ever have practicals where you design the experiment yourself without the help of instructions?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	15	3	18	4	0	4	26	25	51	30	36	66	39	17	56	19	3	22	32	34	66	11	16	27	52	28	80		
B	30	33	63	40	29	69	38	33	71	38	30	68	29	37	66	70	62	132	24	46	70	33	23	56	48	31	79		

	Biology									Chemistry									Physics										
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	12	11	23	8	16	24	12	7	19	4	6	10	6	9	15	1	1	2	10	8	18	16	11	27	26	9	35		
B	6	16	22	9	11	20	9	19	28	13	7	20	8	4	12	12	12	24	19	10	29	21	15	36	8	6	14		

Key

A Yes

B No

5.9b

Percentages

Question : Do you ever have practicals where you design the experiment yourself without the help of instructions?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	33.3	8.3	22.2	9.1	0.0	5.5	40.6	43.1	41.8	44.1	54.5	49.3	57.4	31.5	45.9	21.3	4.6	14.3	57.1	42.5	48.5	25.0	41.0	32.5	52.0	47.5	50.3		
B	66.7	91.7	77.8	90.9	100.0	94.5	59.4	56.9	58.2	55.9	45.5	50.7	42.6	68.5	54.1	78.7	95.4	85.7	42.9	57.5	51.5	75.0	59.0	67.5	48.0	52.5	49.7		

	Biology									Chemistry									Physics										
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	66.7	40.7	51.1	47.1	59.3	54.5	57.1	26.9	40.4	23.5	46.2	33.3	42.9	69.2	55.6	7.7	7.7	7.7	34.5	44.4	38.3	43.2	42.3	42.9	76.5	60.0	71.4		
B	33.3	59.3	48.9	52.9	40.7	45.5	42.9	73.1	59.6	76.5	53.8	66.7	57.1	30.8	44.4	92.3	92.3	92.3	65.5	55.6	61.7	56.8	57.7	57.1	23.5	40.0	28.6		

Key

A Yes

B No

5.10a	Values
Question : Which type of practical work would you prefer?	

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	25	19	44	21	13	34	16	8	24	16	2	18	12	8	20	46	32	78	10	10	20	8	3	11	26	5	31			
B	13	8	21	15	16	31	41	49	90	47	49	96	40	44	84	28	24	52	38	67	105	29	28	57	61	47	108			
C	13	11	24	12	3	15	14	5	19	18	18	36	19	6	25	25	14	39	10	11	21	10	8	18	31	10	41			
O	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0

	Biology						Chemistry						Physics																	
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	3	4	7	4	1	5	3	5	8	3	1	4	3	1	4	2	1	3	10	3	13	9	0	9	7	2	9			
B	13	22	35	13	24	37	12	21	33	10	12	22	9	6	15	10	10	20	18	15	33	25	19	44	18	13	31			
C	2	4	6	2	4	6	6	3	9	5	0	5	4	6	10	1	2	3	7	1	8	12	8	20	12	1	13			
O	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			

Key					
A	Designing your own practical	B	Follow a given set of instructions	C	Teacher demonstrations
O	Other				

5.10b

Percentages

Question : Which type of practical work would you prefer?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	49.0	50.0	49.4	42.0	40.6	41.5	22.5	12.9	18.0	19.8	2.9	12.0	16.9	13.8	15.5	45.5	45.7	45.6	17.2	11.4	13.7	17.0	7.7	12.8	22.0	8.1	17.2		
B	25.5	21.1	23.6	30.0	50.0	37.8	57.7	79.0	67.7	58.0	71.0	64.0	56.3	75.9	65.1	27.7	34.3	30.4	65.5	76.1	71.9	61.7	71.8	66.3	51.7	75.8	60.0		
C	25.5	28.9	27.0	24.0	9.4	18.3	19.7	8.1	14.3	22.2	26.1	24.0	26.8	10.3	19.4	24.8	20.0	22.8	17.2	12.5	14.4	21.3	20.5	20.9	26.3	16.1	22.8		
O	0.0	0.0	0.0	4.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		

	Biology									Chemistry									Physics								
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	16.7	13.3	14.6	21.1	3.4	10.4	14.3	17.2	16.0	16.7	7.7	12.9	18.8	7.7	13.8	15.4	7.7	11.5	28.6	15.8	24.1	19.6	0.0	12.3	18.9	12.5	17.0
B	72.2	73.3	72.9	68.4	82.8	77.1	57.1	72.4	66.0	55.6	92.3	71.0	56.3	46.2	51.7	76.9	76.9	76.9	51.4	78.9	61.1	54.3	70.4	60.3	48.6	81.3	58.5
C	11.1	13.3	12.5	10.5	13.8	12.5	28.6	10.3	18.0	27.8	0.0	16.1	25.0	46.2	34.5	7.7	15.4	11.5	20.0	5.3	14.8	26.1	29.6	27.4	32.4	6.3	24.5
O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Key

A	Designing your own practical	B	Follow a given set of instructions	C	Teacher demonstrations
O	Other				

5.11a

Values

Question : Are the tasks given during your practicals difficult?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	1	0	1	1	1	2	3	1	4	4	2	6	2	1	3	2	1	3	2	1	3	4	3	7	3	0	3			
B	1	1	2	4	4	8	5	9	14	10	7	17	10	8	18	5	5	10	10	9	19	8	12	20	7	3	10			
C	17	18	35	16	11	27	28	18	46	38	28	66	26	21	47	33	29	62	26	35	61	21	16	37	45	16	61			
D	19	17	36	20	10	30	23	22	45	9	26	35	24	21	45	39	27	66	14	27	41	9	8	17	33	34	67			
E	6	1	7	5	3	8	5	8	13	7	3	10	6	3	9	11	4	15	4	8	12	2	0	2	12	6	18			

	Biology									Chemistry									Physics											
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	1	0	1	1	1	2	0	0	0	2	1	3	1	1	2	1	1	2	0	0	0	2	0	2	1	0	1			
B	1	2	3	3	3	6	6	4	10	2	5	7	4	4	8	2	3	5	2	2	4	3	0	3	2	1	3			
C	9	9	18	9	13	22	8	13	21	7	4	11	8	5	13	6	7	13	12	5	17	21	10	31	12	1	13			
D	5	11	16	3	9	12	6	7	13	5	3	8	0	3	3	4	2	6	13	8	21	6	14	20	14	12	26			
E	2	5	7	1	1	2	1	2	3	1	0	1	1	0	1	0	0	0	2	3	5	5	2	7	5	1	6			

Key

A Always  
D Rarely

B Often  
E Never

C Sometimes

5.11b

Percentages

Question : Are the tasks given during your practicals difficult?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	2.3	0.0	1.2	2.2	3.4	2.7	4.7	1.7	3.3	5.9	3.0	4.5	2.9	1.9	2.5	2.2	1.5	1.9	3.6	1.3	2.2	9.1	7.7	8.4	3.0	0.0	1.9		
B	2.3	2.7	2.5	8.7	13.8	10.7	7.8	15.5	11.5	14.7	10.6	12.7	14.7	14.8	14.8	5.6	7.6	6.4	17.9	11.3	14.0	18.2	30.8	24.1	7.0	5.1	6.3		
C	38.6	48.6	43.2	34.8	37.9	36.0	43.8	31.0	37.7	55.9	42.4	49.3	38.2	38.9	38.5	36.7	43.9	39.7	46.4	43.8	44.9	47.7	41.0	44.6	45.0	27.1	38.4		
D	43.2	45.9	44.4	43.5	34.5	40.0	35.9	37.9	36.9	13.2	39.4	26.1	35.3	38.9	36.9	43.3	40.9	42.3	25.0	33.8	30.1	20.5	20.5	20.5	33.0	57.6	42.1		
E	13.6	2.7	8.6	10.9	10.3	10.7	7.8	13.8	10.7	10.3	4.5	7.5	8.8	5.6	7.4	12.2	6.1	9.6	7.1	10.0	8.8	4.5	0.0	2.4	12.0	10.2	11.3		

	Biology									Chemistry									Physics										
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	5.6	0.0	2.2	5.9	3.7	4.5	0.0	0.0	0.0	11.8	7.7	10.0	7.1	7.7	7.4	7.7	7.7	7.7	0.0	0.0	0.0	5.4	0.0	3.2	2.9	0.0	2.0		
B	5.6	7.4	6.7	17.6	11.1	13.6	28.6	15.4	21.3	11.8	38.5	23.3	28.6	30.8	29.6	15.4	23.1	19.2	6.9	11.1	8.5	8.1	0.0	4.8	5.9	6.7	6.1		
C	50.0	33.3	40.0	52.9	48.1	50.0	38.1	50.0	44.7	41.2	30.8	36.7	57.1	38.5	48.1	46.2	53.8	50.0	41.4	27.8	36.2	56.8	38.5	49.2	35.3	6.7	26.5		
D	27.8	40.7	35.6	17.6	33.3	27.3	28.6	26.9	27.7	29.4	23.1	26.7	0.0	23.1	11.1	30.8	15.4	23.1	44.8	44.4	44.7	16.2	53.8	31.7	41.2	80.0	53.1		
E	11.1	18.5	15.6	5.9	3.7	4.5	4.8	7.7	6.4	5.9	0.0	3.3	7.1	0.0	3.7	0.0	0.0	0.0	6.9	16.7	10.6	13.5	7.7	11.1	14.7	6.7	12.2		

Key

A Always  
D RarelyB Often  
E Never

C Sometimes

5.12a

Values

Question : Has the difficulty of practical work changed over the years?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	13	13	26	28	17	45	42	42	84	50	51	101	55	40	95	41	30	71	37	61	98	33	31	64	77	41	118		
B	32	24	56	19	12	31	22	16	38	18	15	33	13	14	27	51	36	87	19	19	38	11	8	19	23	18	41		

	Biology									Chemistry									Physics										
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	8	21	29	14	23	37	15	17	32	12	9	21	10	10	20	11	12	23	22	12	34	26	18	44	29	11	40		
B	10	6	16	3	4	7	6	9	15	5	4	9	4	3	7	2	1	3	7	6	13	11	8	19	5	4	9		

Key

A Yes

B No



5.13a

Values

Question : If yes (question 5.11) how?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	7	8	15	15	11	26	36	41	77	44	48	92	48	35	83	22	19	41	29	57	86	31	30	61	68	37	105		
B	6	5	11	13	6	19	6	1	7	6	3	9	7	5	12	19	11	30	8	4	12	2	1	3	9	4	13		

	Biology									Chemistry									Physics										
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	7	20	27	11	22	33	11	15	26	10	9	19	10	10	20	11	11	22	19	12	31	23	16	39	26	9	35		
B	1	1	2	3	1	4	4	2	6	2	0	2	0	0	0	0	1	1	3	0	3	3	2	5	3	2	5		

Key

A More difficult

B Less difficult

5.13b

Percentages

Question : If yes (question 5.11) how?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	53.8	61.5	57.7	53.6	64.7	57.8	85.7	97.6	91.7	88.0	94.1	91.1	87.3	87.5	87.4	53.7	63.3	57.7	78.4	93.4	87.8	93.9	96.8	95.3	88.3	90.2	89.0			
B	46.2	38.5	42.3	46.4	35.3	42.2	14.3	2.4	8.3	12.0	5.9	8.9	12.7	12.5	12.6	46.3	36.7	42.3	21.6	6.6	12.2	6.1	3.2	4.7	11.7	9.8	11.0			

	Biology						Chemistry						Physics														
	Grade 10		Grade 11		Grade 12		Grade 10		Grade 11		Grade 12		Grade 10		Grade 11		Grade 12										
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T			
A	87.5	95.2	93.1	78.6	95.7	89.2	73.3	88.2	81.3	83.3	100.0	90.5	100.0	100.0	100.0	100.0	91.7	95.7	86.4	100.0	91.2	88.5	88.9	88.6	89.7	81.8	87.5
B	12.5	4.8	6.9	21.4	4.3	10.8	26.7	11.8	18.8	16.7	0.0	9.5	0.0	0.0	0.0	0.0	8.3	4.3	13.6	0.0	8.8	11.5	11.1	11.4	10.3	18.2	12.5

Key

A More difficult

B Less difficult

5.14a

Values

Question : Do you feel that you will perform better in exams because you did practical work?

Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics					
M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	41	33	74	38	26	64	40	47	87	59	55	114	46	43	89	79	59	138	42	61	103	32	31	63	71	53	124		
B	4	4	8	8	2	10	23	10	33	9	11	20	22	11	33	12	6	18	14	18	32	12	8	20	28	6	34		

Biology									Chemistry									Physics											
Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12					
M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	13	21	34	15	22	37	14	18	32	10	10	20	12	11	23	10	10	20	17	16	33	32	22	54	22	15	37		
B	5	5	10	2	5	7	7	8	15	7	3	10	2	2	4	3	3	6	11	2	13	5	4	9	12	0	12		

Key

A Yes

B No

5.14b

Percentages

Question : Do you feel that you will perform better in exams because you did practical work?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	91.1	89.2	90.2	82.6	92.9	86.5	63.5	82.5	72.5	86.8	83.3	85.1	67.6	79.6	73.0	86.8	90.8	88.5	75.0	77.2	76.3	72.7	79.5	75.9	71.7	89.8	78.5		
B	8.9	10.8	9.8	17.4	7.1	13.5	36.5	17.5	27.5	13.2	16.7	14.9	32.4	20.4	27.0	13.2	9.2	11.5	25.0	22.8	23.7	27.3	20.5	24.1	28.3	10.2	21.5		

	Biology									Chemistry									Physics								
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	72.2	80.8	77.3	88.2	81.5	84.1	66.7	69.2	58.1	58.8	76.9	66.7	85.7	84.6	85.2	76.9	76.9	76.9	60.7	88.9	71.7	86.5	84.6	85.7	64.7	100.0	75.5
B	27.8	19.2	22.7	11.8	18.5	15.9	33.3	30.8	31.9	41.2	23.1	33.3	14.3	15.4	14.8	23.1	23.1	23.1	39.3	11.1	28.3	13.5	15.4	14.3	35.3	0.0	24.5

Key

A Yes

B No

5.15a

Values

Question : Does writing reports help you understand the practical work better?

A  
B

Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics					
M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
35	28	63	25	23	48	39	32	71	49	57	106	53	43	96	60	51	111	38	59	97	31	28	59	72	45	117			
9	9	18	22	5	27	25	24	49	19	8	27	15	11	26	31	14	45	18	19	37	13	11	24	28	13	41			

A  
B

Biology									Chemistry									Physics											
Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12					
M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
13	15	28	10	24	34	15	20	35	10	6	16	10	12	22	11	10	21	16	11	27	29	21	50	27	13	40			
5	10	15	7	3	10	6	6	12	7	7	14	4	1	5	2	3	5	13	7	20	8	4	12	7	2	9			

Key

A Yes

B No

5.15b

Percentages

Question : Does writing reports help you understand the practical work better?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	79.5	75.7	77.8	53.2	82.1	64.0	60.9	57.1	59.2	72.1	87.7	79.7	77.9	79.6	78.7	65.9	78.5	71.2	67.9	75.6	72.4	70.5	71.8	71.1	72.0	77.6	74.1		
B	20.5	24.3	22.2	46.8	17.9	36.0	39.1	42.9	40.8	27.9	12.3	20.3	22.1	20.4	21.3	34.1	21.5	28.8	32.1	24.4	27.6	29.5	28.2	28.9	28.0	22.4	25.9		

	Biology									Chemistry									Physics										
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	72.2	60.0	65.1	58.8	88.9	77.3	71.4	76.9	74.5	58.8	46.2	53.3	71.4	92.3	81.5	84.6	76.9	80.8	55.2	61.1	57.4	78.4	84.0	80.6	79.4	86.7	81.6		
B	27.8	40.0	34.9	41.2	11.1	22.7	28.6	23.1	25.5	41.2	53.8	46.7	28.6	7.7	18.5	15.4	23.1	19.2	44.8	38.9	42.6	21.6	16.0	19.4	20.6	13.3	18.4		

Key

A Yes

B No

5.16a

Values

Question : What sort of help are you given to write the report?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	24	20	44	22	17	39	27	34	61	44	40	84	33	31	64	46	37	83	48	75	123	20	14	34	36	16	52
B	10	9	19	11	6	17	42	27	69	34	32	66	38	24	62	21	15	36	28	32	60	24	19	43	62	32	94
C	23	20	43	11	6	17	21	16	37	21	21	42	23	13	36	34	26	60	15	27	42	16	8	24	34	15	49
D	16	12	28	19	12	31	24	14	38	35	26	61	13	9	22	35	24	59	14	21	35	16	6	22	42	22	64
E	4	2	6	4	3	7	6	7	13	17	6	23	12	15	27	8	5	13	9	11	20	6	5	11	20	12	32
F	0	0	0	3	1	4	5	3	8	0	1	1	1	1	2	3	1	4	1	1	2	3	3	6	2	1	3
O	4	0	4	4	2	6	2	2	4	11	20	31	2	2	4	8	2	10	3	6	9	4	8	12	8	10	18

	Biology									Chemistry									Physics								
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	15	24	39	16	27	43	17	24	41	4	6	10	9	4	13	7	4	11	8	4	12	19	9	28	9	3	12
B	12	11	23	7	11	18	9	10	19	9	4	13	8	9	17	7	6	13	21	12	33	19	12	31	22	8	30
C	6	7	13	4	12	16	5	8	13	4	4	8	6	2	8	6	2	8	11	5	16	11	7	18	12	3	15
D	5	4	9	7	8	15	2	9	11	5	1	6	8	5	13	3	0	3	14	9	23	20	13	33	8	0	8
E	2	3	5	3	2	5	4	6	10	2	1	3	3	0	3	1	4	5	2	3	5	11	4	15	7	5	12
F	1	1	2	0	0	0	0	0	0	3	2	5	0	1	1	0	0	0	1	0	1	0	0	0	1	1	2
O	0	0	0	3	6	9	0	0	0	0	2	2	3	6	9	1	0	1	2	0	2	5	8	13	1	2	3

Key

A	Handouts	B	Teacher dictates	C	Copying from board
D	Textbook	E	Work in a group	F	None
O	Other				

5.16b

Percentages

Question : What sort of help are you given to write the report?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	29.6	31.7	30.6	29.7	36.2	32.2	21.3	33.0	26.5	27.2	27.4	27.3	27.0	32.6	29.5	29.7	33.6	31.3	40.7	43.4	42.3	22.5	22.2	22.4	17.6	14.8	16.7		
B	12.3	14.3	13.2	14.9	12.8	14.0	33.1	26.2	30.0	21.0	21.9	21.4	31.1	25.3	28.6	13.5	13.6	13.6	23.7	18.5	20.6	27.0	30.2	28.3	30.4	29.6	30.1		
C	28.4	31.7	29.9	14.9	12.8	14.0	16.5	15.5	16.1	13.0	14.4	13.6	18.9	13.7	16.6	21.9	23.6	22.6	12.7	15.6	14.4	18.0	12.7	15.8	16.7	13.9	15.7		
D	19.8	19.0	19.4	25.7	25.5	25.6	18.9	13.6	16.5	21.6	17.8	19.8	10.7	9.5	10.1	22.6	21.8	22.3	11.9	12.1	12.0	18.0	9.5	14.5	20.6	20.4	20.5		
E	4.9	3.2	4.2	5.4	6.4	5.8	4.7	6.8	5.7	10.5	4.1	7.5	9.8	15.8	12.4	5.2	4.5	4.9	7.6	6.4	6.9	6.7	7.9	7.2	9.8	11.1	10.3		
F	0.0	0.0	0.0	4.1	2.1	3.3	3.9	2.9	3.5	0.0	0.7	0.3	0.8	1.1	0.9	1.9	0.9	1.5	0.8	0.6	0.7	3.4	4.8	3.9	1.0	0.9	1.0		
O	4.9	0.0	2.8	5.4	4.3	5.0	1.6	1.9	1.7	6.8	13.7	10.1	1.6	2.1	1.8	5.2	1.8	3.8	2.5	3.5	3.1	4.5	12.7	7.9	3.9	9.3	5.8		

	Biology									Chemistry									Physics										
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	36.6	48.0	42.9	40.0	40.9	40.6	45.9	42.1	43.6	14.8	30.0	21.3	24.3	14.8	20.3	28.0	25.0	26.8	13.6	12.1	13.0	22.4	17.0	20.3	15.0	13.6	14.6		
B	29.3	22.0	25.3	17.5	16.7	17.0	24.3	17.5	20.2	33.3	20.0	27.7	21.6	33.3	26.6	28.0	37.5	31.7	35.6	36.4	35.9	22.4	22.6	22.5	36.7	36.4	36.6		
C	14.6	14.0	14.3	10.0	18.2	15.1	13.5	14.0	13.8	14.8	20.0	17.0	16.2	7.4	12.5	24.0	12.5	19.5	18.6	15.2	17.4	12.9	13.2	13.0	20.0	13.6	18.3		
D	12.2	8.0	9.9	17.5	12.1	14.2	5.4	15.8	11.7	18.5	5.0	12.8	21.6	18.5	20.3	12.0	0.0	7.3	23.7	27.3	25.0	23.5	24.5	23.9	13.3	0.0	9.8		
E	4.9	6.0	5.5	7.5	3.0	4.7	10.8	10.5	10.6	7.4	5.0	6.4	8.1	0.0	4.7	4.0	25.0	12.2	3.4	9.1	5.4	12.9	7.5	10.9	11.7	22.7	14.6		
F	2.4	2.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	11.1	10.0	10.6	0.0	3.7	1.6	0.0	0.0	0.0	1.7	0.0	1.1	0.0	0.0	0.0	1.7	4.5	2.4		
O	0.0	0.0	0.0	7.5	9.1	8.5	0.0	0.0	0.0	0.0	10.0	4.3	8.1	22.2	14.1	4.0	0.0	2.4	3.4	0.0	2.2	5.9	15.1	9.4	1.7	9.1	3.7		

Key

A Handouts  
D Textbook  
O Other

B Teacher dictates  
E Work in a group

C Copying from board  
F None

5.17a

Values

Question : In the report what sort of results do you include?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	30	27	57	35	17	52	51	42	93	60	54	114	54	43	97	65	44	109	45	62	107	36	30	66	84	47	131		
B	11	4	15	7	6	13	7	12	19	14	10	24	9	9	18	18	10	28	9	14	23	4	5	9	17	12	29		
C	11	10	21	10	7	17	18	14	32	6	10	16	14	10	24	21	17	38	12	20	32	12	8	20	14	6	20		

	Biology									Chemistry									Physics								
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	15	19	34	15	22	37	15	21	36	13	11	24	12	10	22	11	9	20	23	12	35	33	22	55	28	13	41
B	2	4	6	2	5	7	5	5	10	1	2	3	3	1	4	0	2	2	4	6	10	9	4	13	4	2	6
C	5	9	14	2	6	8	5	5	10	8	3	11	1	2	3	3	3	6	5	2	7	3	2	5	6	2	8

Key

<b>A</b>	Results you obtained from the practical	<b>B</b>	Your results modified/corrected by the teacher	<b>C</b>	Expected results - what was supposed to happen
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5.17b

Percentages

Question : In the report what sort of results do you include?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	57.7	65.9	61.3	67.3	56.7	63.4	67.1	61.8	64.6	75.0	73.0	74.0	70.1	69.4	69.8	62.5	62.0	62.3	68.2	64.6	66.0	69.2	69.8	69.5	73.0	72.3	72.8			
B	21.2	9.8	16.1	13.5	20.0	15.9	9.2	17.6	13.2	7.5	13.5	15.6	11.7	14.5	12.9	17.3	14.1	16.0	13.6	14.6	14.2	7.7	11.6	9.5	14.8	18.5	16.1			
C	21.2	24.4	22.6	19.2	23.3	20.7	23.7	20.6	22.2	7.5	13.5	10.4	18.2	16.1	17.3	20.2	23.9	21.7	18.2	20.8	19.8	23.1	18.6	21.1	12.2	9.2	11.1			

	Biology						Chemistry						Physics														
	Grade 10		Grade 11		Grade 12		Grade 10		Grade 11		Grade 12		Grade 10		Grade 11		Grade 12										
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	68.2	59.4	63.0	78.9	66.7	71.2	60.0	67.7	64.3	59.1	68.8	63.2	75.0	76.9	75.9	78.6	64.3	71.4	71.9	60.0	67.3	73.3	78.6	75.3	73.7	76.5	74.5
B	9.1	12.5	11.1	10.5	15.2	13.5	20.0	16.1	17.9	4.5	12.5	7.9	18.8	7.7	13.8	0.0	14.3	7.1	12.5	30.0	19.2	20.0	14.3	17.8	10.5	11.8	10.9
C	22.7	28.1	25.9	10.5	18.2	15.4	20.0	16.1	17.9	36.4	18.8	28.9	6.3	15.4	10.3	21.4	21.4	21.4	15.6	10.0	13.5	6.7	7.1	6.8	15.8	11.8	14.5

Key

A	Results you obtained from the practical	B	Your results modified/corrected by the teacher	C	Expected results - what was supposed to happen
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5.18a

Values

Question : Which part of the report do you think is the most important?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	5	0	5	3	3	6	5	5	10	7	4	11	7	5	12	8	3	11	5	8	13	3	2	5	11	4	15		
B	2	0	2	1	C	1	1	0	1	3	0	3	0	0	0	3	0	3	2	0	2	1	0	1	1	0	1		
C	26	19	45	15	11	26	17	21	38	26	20	46	23	11	34	41	30	71	20	28	48	11	6	17	35	18	53		
D	4	4	8	13	5	18	10	22	32	21	24	45	15	13	28	17	9	26	14	25	39	11	14	25	21	20	41		
E							4	0	4	8	2	10	1	4	5				4	2	6	4	1	5	5	3	8		
F							3	3	6	8	4	12	0	0	0				4	3	7	3	1	4	4	3	7		
G				4	5	9	15	15	30	23	25	48	22	28	50	4	5	9	15	28	43	13	15	28	32	25	57		
H							13	3	16	27	17	44	11	26	37				20	28	48	13	8	21	18	10	28		
I	16	16	32	13	11	24	18	7	25	15	18	33	17	2	19	29	27	56	13	11	24	11	6	17	26	10	36		

	Biology									Chemistry									Physics										
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	1	3	4	2	3	5	2	2	4	1	1	2	1	0	1	1	1	2	3	1	4	4	1	5	4	2	6		
B	1	0	1	1	C	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	1	0	0	0		
C	6	13	19	6	10	16	8	5	13	3	2	5	5	2	7	3	2	5	8	6	14	15	8	23	12	4	16		
D	3	8	11	5	10	15	6	7	13	2	6	8	5	4	9	4	4	8	5	8	13	11	10	21	5	2	7		
E	1	0	1	3	1	4	0	1	1	2	0	2	2	0	2	0	1	1	1	0	1	3	1	4	1	2	3		
F	1	1	2	3	2	5	0	0	0	1	1	2	2	0	2	0	0	0	1	1	2	3	2	5	0	0	0		
G	3	6	9	6	11	17	6	11	17	4	3	7	5	4	9	4	8	12	8	6	14	12	10	22	12	9	21		
H	4	2	6	11	11	22	5	15	20	4	1	5	7	2	9	2	5	7	5	0	5	9	4	13	4	6	10		
I	5	3	8	4	6	10	4	2	6	6	2	8	2	4	6	3	0	3	7	2	9	9	8	17	10	0	10		

Key

A Aim  
D Result  
G Conclusion

B Apparatus  
E Precautions  
H Discussion

C Method  
F Sources of error  
I All the same

5.18b

Percentages

Question : Which part of the report do you think is the most important?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	9.4	0.0	5.4	6.1	8.6	7.1	5.8	6.6	6.2	5.1	3.5	4.4	7.3	5.6	6.5	7.8	4.1	6.3	5.2	6.0	5.7	4.3	3.8	4.1	7.2	4.3	6.1		
B	3.8	0.0	2.2	2.0	0.0	1.2	1.2	0.0	0.6	2.2	0.0	1.2	0.0	0.0	0.0	2.9	0.0	1.7	2.1	0.0	0.9	1.4	0.0	0.8	0.7	0.0	0.4		
C	49.1	48.7	48.9	30.6	31.4	31.0	19.8	27.6	23.5	18.8	17.5	18.3	24.0	12.4	18.4	40.2	40.5	40.3	20.6	21.1	20.9	15.7	11.3	13.8	22.9	19.4	21.5		
D	7.5	10.3	8.7	26.5	14.3	21.4	11.6	28.9	19.8	15.2	21.1	17.9	15.6	14.6	15.1	16.7	12.2	14.8	14.4	18.8	17.0	15.7	26.4	20.3	13.7	21.5	16.7		
E							4.7	0.0	2.5	5.8	1.8	4.0	1.0	4.5	2.7				4.1	1.5	2.6	5.7	1.9	4.1	3.3	3.2	3.3		
F							3.5	3.9	3.7	5.8	3.5	4.8	0.0	0.0	0.0				4.1	2.3	3.0	4.3	1.9	3.3	2.6	3.2	2.8		
G				8.2	14.3	10.7	17.4	19.7	18.5	16.7	21.9	19.0	22.9	31.5	27.0	3.9	6.8	5.1	15.5	21.1	18.7	18.6	28.3	22.8	20.9	26.9	23.2		
H							15.1	3.9	9.9	19.6	14.9	17.5	11.5	29.2	20.0				20.6	21.1	20.9	18.6	15.1	17.1	11.8	10.8	11.4		
I	30.2	41.0	34.8	26.5	31.4	28.6	20.9	9.2	15.4	10.9	15.8	13.1	17.7	2.2	10.3	28.4	36.5	31.8	13.4	8.3	10.4	15.7	11.3	13.8	17.0	10.8	14.6		

	Biology									Chemistry									Physics										
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	4.0	8.3	6.6	4.9	5.6	5.3	6.5	4.7	5.4	4.3	6.3	5.1	3.3	0.0	2.2	5.9	4.8	5.3	7.9	4.2	6.5	6.0	2.3	4.5	8.3	8.0	8.2		
B	4.0	0.0	1.6	2.4	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.9	0.0	0.0	0.0		
C	24.0	36.1	31.1	14.6	18.5	16.8	25.8	11.6	17.6	13.0	12.5	12.8	16.7	12.5	15.2	17.6	9.5	13.2	21.1	25.0	22.6	22.4	18.2	20.7	25.0	16.0	21.9		
D	12.0	22.2	18.0	12.2	18.5	15.8	19.4	16.3	17.6	8.7	37.5	20.5	16.7	25.0	19.6	23.5	19.0	21.1	13.2	33.3	21.0	16.4	22.7	18.9	10.4	8.0	9.6		
E	4.0	0.0	1.6	7.3	1.9	4.2	0.0	2.3	1.4	8.7	0.0	5.1	6.7	0.0	4.3	0.0	4.8	2.6	2.6	0.0	1.6	4.5	2.3	3.6	2.1	8.0	4.1		
F	4.0	2.8	3.3	7.3	3.7	5.3	0.0	0.0	0.0	4.3	6.3	5.1	6.7	0.0	4.3	0.0	0.0	0.0	2.6	4.2	3.2	4.5	4.5	4.5	0.0	0.0	0.0		
G	12.0	16.7	14.8	14.6	20.4	17.9	19.4	25.6	23.0	17.4	18.8	17.9	16.7	25.0	19.6	23.5	38.1	31.6	21.1	25.0	22.6	17.9	22.7	19.8	25.0	36.0	28.8		
H	16.0	5.6	9.8	26.8	20.4	23.2	16.1	34.9	27.0	17.4	6.3	12.8	23.3	12.5	19.6	11.8	23.8	18.4	13.2	0.0	8.1	13.4	9.1	11.7	8.3	24.0	13.7		
I	20.0	8.3	13.1	9.8	11.1	10.5	12.9	4.7	8.1	26.1	12.5	20.5	6.7	25.0	13.0	17.6	0.0	7.9	18.4	8.3	14.5	13.4	18.2	15.3	20.8	0.0	13.7		

Key

A	Aim	B	Apparatus	C	Method
D	Result	E	Precautions	F	Sources of error
G	Conclusion	H	Discussion	I	All the same

5.19a

Values

Question : Which part of the report do you think is the least important?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	17	18	35	8	6	14	7	18	25	15	14	29	10	10	20	25	24	49	8	15	23	9	13	22	15	14	29		
B	10	4	14	12	9	21	22	19	41	36	21	57	12	26	38	22	13	35	20	25	45	15	14	29	35	27	62		
C	3	0	3	5	6	5	0	1	1	3	0	3	1	1	2	8	0	8	1	2	3	1	0	1	2	0	2		
D	5	1	6	1	1	2	0	0	0	0	0	0	1	0	1	6	2	8	0	0	0	0	0	0	1	0	1		
E							8	8	16	6	8	14	10	11	21				8	17	25	7	2	9	9	8	17		
F							6	8	14	9	9	18	22	18	40				11	21	32	7	4	11	19	10	29		
G				12	5	17	5	2	7	10	2	12	2	0	2	12	5	17	6	2	8	4	0	4	7	2	9		
H							13	2	15	10	7	17	8	1	9				8	6	14	5	1	6	18	3	21		
I	13	14	27	10	8	18	14	4	18	9	17	26	10	1	11	23	22	45	8	8	16	7	7	14	18	7	25		

	Biology									Chemistry									Physics										
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	1	8	9	4	5	9	3	2	5	3	5	8	4	4	8	2	4	6	3	5	8	7	5	12	5	4	9		
B	7	7	14	11	8	19	2	10	12	5	5	10	8	2	10	2	7	9	10	7	17	17	11	28	8	9	17		
C	0	1	1	1	0	1	0	1	1	0	0	0	1	0	1	0	0	0	0	0	0	1	0	1	1	0	1		
D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1		
E	3	5	8	2	4	6	3	8	11	2	0	2	2	1	3	3	1	4	3	3	6	2	3	5	4	2	6		
F	0	4	4	2	5	7	9	12	21	1	1	2	2	1	3	4	2	6	5	3	8	5	3	8	9	4	13		
G	2	2	4	3	0	3	1	0	1	1	0	1	2	0	2	1	0	1	2	0	2	5	2	7	0	0	0		
H	4	1	5	1	4	5	3	1	4	3	0	3	1	1	2	1	0	1	6	1	7	8	2	10	4	0	4		
I	3	1	4	3	6	9	2	1	3	5	2	7	1	5	6	1	0	1	6	1	7	5	6	11	7	0	7		

Key

A Aim  
D Result  
G Conclusion

B Apparatus  
E Precautions  
H Discussion

C Method  
F Sources of error  
I All the same

5.19b

Percentages

Question : Which part of the report do you think is the least important?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	35.4	48.6	41.2	16.7	20.7	18.2	9.3	29.0	18.2	15.3	17.9	16.5	13.2	14.7	13.9	26.0	36.4	30.2	11.4	15.6	13.9	16.4	31.7	22.9	12.1	19.7	14.9		
B	20.8	10.8	16.5	25.0	31.0	27.3	29.3	30.6	29.9	36.7	26.9	32.4	15.8	38.2	26.4	22.9	19.7	21.6	28.6	26.0	27.1	27.3	34.1	30.2	28.2	38.0	31.8		
C	6.3	0.0	3.5	10.4	0.0	6.5	0.0	1.6	0.7	3.1	0.0	1.7	1.3	1.5	1.4	8.3	0.0	4.9	1.4	2.1	1.8	1.8	0.0	1.0	1.6	0.0	1.0		
D	10.4	2.7	7.1	2.1	3.4	2.6	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.7	6.3	3.0	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.5		
E							10.7	12.9	11.7	6.1	10.3	8.0	13.2	16.2	14.6				11.4	17.7	15.1	12.7	4.9	9.4	7.3	11.3	8.7		
F							8.0	12.9	10.2	9.2	11.5	10.2	28.9	26.5	27.8				15.7	21.9	19.3	12.7	9.8	11.5	15.3	14.1	14.9		
G				25.0	17.2	22.1	6.7	3.2	5.1	10.2	2.6	6.8	2.6	0.0	1.4	12.5	7.6	10.5	8.6	2.1	4.8	7.3	0.0	4.2	5.6	2.8	4.6		
H							17.3	3.2	10.9	10.2	9.0	9.7	10.5	1.5	6.3				11.4	6.3	8.4	9.1	2.4	6.3	14.5	4.2	10.8		
I	27.1	37.8	31.8	20.8	27.6	23.4	18.7	6.5	13.1	9.2	21.8	14.8	13.2	1.5	7.6	24.0	33.3	27.8	11.4	8.3	9.6	12.7	17.1	14.6	14.5	9.9	12.8		

	Biology									Chemistry									Physics										
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	5.0	27.6	18.4	14.8	15.6	15.3	13.0	5.7	8.6	15.0	38.5	24.2	19.0	28.6	22.9	14.3	28.6	21.4	8.6	25.0	14.5	14.0	15.6	14.6	12.8	21.1	15.5		
B	35.0	24.1	28.6	40.7	25.0	32.2	8.7	28.6	20.7	25.0	38.5	30.3	38.1	14.3	28.6	14.3	50.0	32.1	28.6	35.0	30.9	34.0	34.4	34.1	20.5	47.4	29.3		
C	0.0	3.4	2.0	3.7	0.0	1.7	0.0	2.9	1.7	0.0	0.0	0.0	4.8	0.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	1.2	2.6	0.0	1.7		
D	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0	1.7		
E	15.0	17.2	16.3	7.4	12.5	10.2	13.0	22.9	19.0	10.0	0.0	6.1	9.5	7.1	8.6	21.4	7.1	14.3	8.6	15.0	10.9	4.0	9.4	6.1	10.3	10.5	10.3		
F	0.0	13.8	8.2	7.4	15.6	11.9	39.1	34.3	36.2	5.0	7.7	6.1	9.5	7.1	8.6	28.6	14.3	21.4	14.3	15.0	14.5	10.0	9.4	9.8	23.1	21.1	22.4		
G	10.0	6.9	8.2	11.1	0.0	5.1	4.3	0.0	1.7	5.0	0.0	3.0	9.5	0.0	5.7	7.1	0.0	3.6	5.7	0.0	3.6	10.0	6.3	8.5	0.0	0.0	0.0		
H	20.0	3.4	10.2	3.7	12.5	8.5	13.0	2.9	6.9	15.0	0.0	9.1	4.8	7.1	5.7	7.1	0.0	3.6	17.1	5.0	12.7	16.0	6.3	12.2	10.3	0.0	6.9		
I	15.0	3.4	8.2	11.1	18.8	15.3	8.7	2.9	5.2	25.0	15.4	21.2	4.8	35.7	17.1	7.1	0.0	3.6	17.1	5.0	12.7	10.0	18.8	13.4	17.9	0.0	12.1		

Key

A	Aim	B	Apparatus	C	Method
D	Result	E	Precautions	F	Sources of error
G	Conclusion	H	Discussion	I	All the same

5.20a

Values

Question : On average how many marks do you usually obtain for your report?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	39	33	72	36	24	60	52	49	101	50	55	105	51	47	98	75	57	132	40	64	104	37	31	68	76	56	132			
B	4	3	7	10	2	12	11	8	19	18	11	29	16	7	23	14	5	19	16	15	31	7	8	15	22	3	25			
C	1	1	2	0	2	2	1	1	2	0	0	0	1	0	1	1	3	4	0	1	1	0	0	0	2	0	2			

	Biology									Chemistry									Physics											
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	14	23	37	12	20	32	14	21	35	15	8	23	12	12	24	10	11	21	23	18	41	26	23	49	27	15	42			
B	4	3	7	5	7	12	7	5	12	2	5	7	2	1	3	3	2	5	5	0	5	11	3	14	6	0	6			
C	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	1			

Key

A 13 to 15

B 9 to 12

C 8 or less

5.20b

Percentages

Question : On average how many marks do you usually obtain for your report?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	88.6	89.2	88.9	78.3	85.7	81.1	81.3	84.5	82.8	73.5	83.3	78.4	75.0	87.0	80.3	83.3	87.7	85.2	71.4	80.0	76.5	84.1	79.5	81.9	76.0	94.9	83.0			
B	9.1	8.1	8.6	21.7	7.1	16.2	17.2	13.8	15.6	26.5	16.7	21.6	23.5	13.0	18.9	15.6	7.7	12.3	28.6	18.8	22.8	15.9	20.5	18.1	22.0	5.1	15.7			
C	2.3	2.7	2.5	0.0	7.1	2.7	1.6	1.7	1.6	0.0	0.0	0.0	1.5	0.0	0.8	1.1	4.6	2.6	0.0	1.3	0.7	0.0	0.0	0.0	2.0	0.0	1.3			

	Biology						Chemistry						Physics																	
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	77.8	85.2	82.2	70.6	74.1	72.7	66.7	80.8	74.5	88.2	61.5	76.7	85.7	92.3	88.9	76.9	84.6	80.8	79.3	100.0	87.2	70.3	88.5	77.8	79.4	100.0	85.7			
B	22.2	11.1	15.6	29.4	25.9	27.3	33.3	19.2	25.5	11.8	38.5	23.3	14.3	7.7	11.1	23.1	15.4	19.2	17.2	0.0	10.6	29.7	11.5	22.2	17.6	0.0	12.2			
C	0.0	3.7	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0	2.1	0.0	0.0	0.0	2.9	0.0	2.0			

Key

A 13 to 15

B 9 to 12

C 8 or less

5.21a

Values

Question : Should marks be given for reports?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	38	32	70	39	25	64	48	51	99	58	62	120	57	49	106	77	57	134	46	73	119	34	34	68	83	55	138
B	7	5	12	8	4	12	16	7	23	10	4	14	11	5	16	15	9	24	10	7	17	10	5	15	17	4	21

	Biology						Chemistry						Physics														
	Grade 10		Grade 11		Grade 12		Grade 10		Grade 11		Grade 12		Grade 10		Grade 11		Grade 12										
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T			
A	14	24	38	14	26	40	18	23	41	11	11	22	12	12	24	11	11	22	23	16	39	32	24	56	28	15	43
B	4	3	7	3	4	4	3	3	6	6	2	8	2	1	3	2	2	4	6	2	8	5	2	7	6	0	6

Key

A Yes

B No

5.21b

Percentages

Question : Should marks be given for reports?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	84.4	86.5	85.4	83.0	86.2	84.2	75.0	87.9	81.1	35.3	93.9	89.6	83.8	90.7	86.9	83.7	86.4	84.8	82.1	91.3	87.5	77.3	87.2	81.9	83.0	93.2	86.8			
B	15.6	13.5	14.6	17.0	13.8	15.8	25.0	12.1	18.9	14.7	6.1	10.4	16.2	9.3	13.1	16.3	13.6	15.2	17.9	8.8	12.5	22.7	12.8	18.1	17.0	6.8	13.2			

	Biology						Chemistry						Physics																	
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	77.8	88.9	84.4	82.4	96.3	90.9	85.7	88.5	87.2	64.7	84.6	73.3	85.7	92.3	88.9	84.6	84.6	84.6	79.3	88.9	83.0	86.5	92.3	88.9	82.4	100.0	87.8			
B	22.2	11.1	15.6	17.6	3.7	9.1	14.3	11.5	12.8	35.3	15.4	26.7	14.3	7.7	11.1	15.4	15.4	15.4	20.7	11.1	17.0	13.5	7.7	11.1	17.6	0.0	12.2			

Key

A Yes

B No

5.22a

Values

Question : Should each part of the report be equally important when calculating the final mark?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	26	21	47	24	17	41	39	24	63	28	23	51	18	12	30	50	38	88	23	27	50	17	12	29	45	20	65			
B	18	14	32	23	12	35	25	34	59	40	43	83	50	42	92	41	26	67	33	53	86	27	27	54	55	39	94			

	Biology						Chemistry						Physics														
	Grade 10		Grade 11		Grade 12		Grade 10		Grade 11		Grade 12		Grade 10		Grade 11		Grade 12										
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T			
A	13	11	24	5	9	14	5	7	12	10	5	15	5	5	10	2	2	4	16	8	24	18	9	27	11	3	14
B	5	16	21	12	18	30	16	19	35	7	8	15	9	8	17	11	11	22	13	10	23	19	17	36	23	12	35

Key

A Each part equally important      B Some parts more important than others

5.22b

Percentages

Question : Should each part of the report be equally important when calculating the final mark?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	59.1	60.0	59.5	51.1	58.6	53.9	60.9	41.4	51.6	41.2	34.8	38.1	26.5	22.2	24.6	54.9	59.4	56.8	41.1	33.8	36.8	38.6	30.8	34.9	45.0	33.9	40.9			
B	40.9	40.0	40.5	48.9	41.4	46.1	39.1	58.6	48.4	58.8	65.2	61.9	73.5	77.8	75.4	45.1	40.6	43.2	58.9	66.3	63.2	61.4	69.2	65.1	55.0	66.1	59.1			

	Biology						Chemistry						Physics																	
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	72.2	40.7	53.3	29.4	33.3	31.8	23.8	26.9	25.5	58.8	38.5	50.0	35.7	38.5	37.0	15.4	15.4	15.4	55.2	44.4	51.1	48.6	34.6	42.9	32.4	20.0	28.6			
B	27.8	59.3	46.7	70.6	66.7	68.2	76.2	73.1	74.5	41.2	61.5	50.0	64.3	61.5	63.0	84.6	84.6	84.6	44.8	55.6	48.9	51.4	65.4	57.1	67.6	80.0	71.4			

Key

A	Each part equally important	B	Some parts more important than others
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5.23a

Values

Question : Do you think that marks should be given for the actual practical besides the report?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	24	14	38	24	17	41	35	31	66	57	27	84	45	24	69	48	31	79	38	39	77	29	16	45	70	27	97			
B	20	22	42	23	12	35	29	27	56	9	36	45	23	30	53	43	34	77	17	40	57	15	22	37	29	31	60			

	Biology						Chemistry						Physics														
	Grade 10		Grade 11		Grade 12		Grade 10		Grade 11		Grade 12		Grade 10		Grade 11		Grade 12										
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T			
A	10	17	27	13	11	24	15	11	26	8	5	13	12	4	16	9	7	16	17	9	26	32	12	44	21	6	27
B	8	10	18	3	15	18	6	15	21	9	8	17	2	8	10	4	6	10	12	9	21	4	13	17	13	9	22

Key

A Yes

B No

5.23b

Percentages

Question : Do you think that marks should be given for the actual practical besides the report?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	54.5	38.9	47.5	51.1	58.6	53.9	54.7	53.4	54.1	86.4	42.9	65.1	66.2	44.4	56.6	52.7	47.7	50.6	69.1	49.4	57.5	65.9	42.1	54.9	70.7	46.6	61.8			
B	45.5	61.1	52.5	48.9	41.4	46.1	45.3	46.6	45.9	13.6	57.1	34.9	33.8	55.6	43.4	47.3	52.3	49.4	30.9	50.6	42.5	34.1	57.9	45.1	29.3	53.4	38.2			

	Biology						Chemistry						Physics																	
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	55.6	63.0	60.0	81.3	42.3	57.1	71.4	42.3	55.3	47.1	38.5	43.3	85.7	33.3	61.5	69.2	53.8	61.5	58.6	50.0	55.3	88.9	48.0	72.1	61.8	40.0	55.1			
B	44.4	37.0	40.0	18.8	57.7	42.9	28.6	57.7	44.7	52.9	61.5	56.7	14.3	66.7	38.5	30.8	46.2	38.5	41.4	50.0	44.7	11.1	52.0	27.9	38.2	60.0	44.9			

Key

A Yes

B No

5.24a

Values

Question : Should the average marks for reports be part of the annual examination mark?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	19	20	39	23	14	37	37	38	75	53	60	113	44	52	96	42	34	76	38	70	108	28	32	60	68	48	116		
B	25	16	41	25	15	40	27	20	47	15	3	18	24	2	26	50	31	81	18	9	27	16	6	22	32	10	42		

	Biology									Chemistry									Physics										
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	12	21	33	12	25	37	14	24	38	8	7	15	11	12	23	9	13	22	17	10	27	30	23	53	21	15	36		
B	6	6	12	5	1	6	7	2	9	9	6	15	3	0	3	4	0	4	12	8	20	7	2	9	13	0	13		

Key

A Yes

B No

5.24b

Percentages

Question : Should the average marks for reports be part of the annual examination mark?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	43.2	55.6	48.8	47.9	48.3	48.1	57.8	65.5	61.5	77.9	95.2	86.3	64.7	96.3	78.7	45.7	52.3	48.4	67.9	88.6	80.0	63.6	84.2	73.2	68.0	82.8	73.4		
B	56.8	44.4	51.3	52.1	51.7	51.9	42.2	34.5	38.5	22.1	4.8	13.7	35.3	3.7	21.3	54.3	47.7	51.6	32.1	11.4	20.0	36.4	15.8	26.8	32.0	17.2	26.6		

	Biology									Chemistry									Physics								
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	66.7	77.8	73.3	70.6	96.2	86.0	66.7	92.3	80.9	47.1	53.8	50.0	78.6	100.0	88.5	69.2	100.0	84.6	58.6	55.6	57.4	81.1	92.0	85.5	61.8	100.0	73.5
B	33.3	22.2	26.7	29.4	3.8	14.0	33.3	7.7	19.1	52.9	46.2	50.0	21.4	0.0	11.5	30.8	0.0	15.4	41.4	44.4	42.6	18.9	8.0	14.5	38.2	0.0	26.5

Key

A Yes

B No

5.25a

Values

Question : Do you enjoy practical work?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	0	0	0	2	2	4	6	2	8	3	4	7	19	2	21	2	2	4	7	3	10	7	3	10	14	2	16		
B	0	1	1	3	0	3	3	0	3	1	5	6	8	8	16	3	1	4	5	8	13	2	3	5	5	2	7		
C	1	1	2	2	3	5	6	7	13	5	8	13	9	6	15	3	4	7	10	9	19	4	5	9	6	7	13		
D	10	6	16	16	13	29	21	23	44	27	31	58	21	25	46	26	19	45	17	37	54	12	16	28	40	26	66		
E	34	28	62	24	1	35	28	26	54	32	18	50	11	13	24	58	39	97	17	23	40	19	12	31	35	22	57		

	Biology									Chemistry									Physics										
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	0	1	1	1	2	3	6	0	6	3	1	4	0	1	1	4	1	5	3	0	3	2	1	3	9	1	10		
B	2	0	2	0	4	4	3	4	7	0	0	0	0	1	1	2	2	4	1	0	1	1	0	1	3	2	5		
C	4	3	7	3	3	6	3	3	6	2	2	4	0	1	1	2	2	4	0	2	2	2	4	6	4	1	5		
D	5	11	16	4	1	15	8	15	23	5	5	10	5	8	13	2	3	5	11	7	18	18	12	30	11	7	18		
E	7	12	19	9	7	16	1	4	5	7	5	12	9	2	11	3	5	8	14	9	23	14	9	23	7	4	11		

Key

A No  
D Quite

B A little  
E A lot

C Indifferent

5.25b

Percentages

Question : Do you enjoy practical work?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	0.0	0.0	0.0	4.3	6.9	5.3	9.4	3.4	6.6	4.4	6.1	5.2	27.9	3.7	17.2	2.2	3.1	2.5	12.5	3.8	7.4	15.9	7.7	12.0	14.0	3.4	10.1		
B	0.0	2.8	1.2	6.4	0.0	3.9	4.7	0.0	2.5	1.5	7.6	4.5	11.8	14.8	13.1	3.3	1.5	2.5	8.9	10.0	9.6	4.5	7.7	6.0	5.0	3.4	4.4		
C	2.2	2.8	2.5	4.3	10.5	6.6	9.4	12.1	10.7	7.4	12.1	9.7	13.2	11.1	12.3	3.3	6.2	4.5	17.9	11.3	14.0	9.1	12.8	10.8	6.0	11.9	8.2		
D	22.2	16.7	19.8	34.0	44.8	38.2	32.8	39.7	36.1	39.7	47.0	43.3	30.9	46.3	37.7	28.3	29.2	28.7	30.4	46.3	39.7	27.3	41.0	33.7	40.0	44.1	41.5		
E	75.6	77.8	76.5	51.1	37.9	46.1	43.8	44.8	44.3	47.1	27.3	37.3	16.2	24.1	19.7	63.0	60.0	61.8	30.4	28.8	29.4	43.2	30.8	37.3	35.0	37.3	35.8		

	Biology									Chemistry									Physics								
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	0.0	3.7	2.2	5.9	7.4	6.8	28.6	0.0	12.8	17.6	7.7	13.3	0.0	7.7	3.7	30.8	7.7	19.2	10.3	0.0	6.4	5.4	3.8	4.8	26.5	6.7	20.4
B	11.1	0.0	4.4	0.0	14.8	9.1	14.3	15.4	14.9	0.0	0.0	0.0	0.0	7.7	3.7	15.4	15.4	15.4	3.4	0.0	2.1	2.7	0.0	1.6	8.8	13.3	10.2
C	22.2	11.1	15.6	17.6	11.1	13.6	14.3	11.5	12.8	11.8	15.4	13.3	0.0	7.7	3.7	15.4	15.4	15.4	0.0	11.1	4.3	5.4	15.4	9.5	11.8	6.7	10.2
D	27.8	40.7	35.6	23.5	40.7	34.1	38.1	57.7	48.9	29.4	38.5	33.3	35.7	61.5	48.1	15.4	23.1	19.2	37.9	38.9	38.3	48.6	46.2	47.6	32.4	46.7	36.7
E	38.9	44.4	42.2	52.9	25.9	36.4	4.8	15.4	10.6	41.2	38.5	40.0	64.3	15.4	40.7	23.1	38.5	30.8	48.3	50.0	48.9	37.8	34.6	36.5	20.6	26.7	22.4

Key

A No  
D QuiteB A little  
E A lot

C Indifferent

5.26a

Values

Question : Which Science subject practicals do you prefer?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	7	10	17	10	10	20	3	11	14	14	12	26	14	16	30				11	16	27	10	14	24	10	9	19
B	4	14	18	5	3	8	13	14	27	11	10	21	6	13	19				9	13	22	11	14	25	10	10	20
C	27	7	34	11	4	15	10	8	18	5	18	23	12	8	20				8	13	21	6	8	14	13	13	26
D	8	12	20	22	1	33	23	8	31	17	11	28	11	0	11				16	8	24	19	3	22	16	8	24
E							19	16	35	21	15	36	26	17	43				11	28	39	0	0	0	55	20	75

	Biology									Chemistry									Physics								
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	1	5	6	5	5	10	5	6	11	1	4	5	4	4	8	5	6	11	1	2	3	5	3	8	4	4	8
B	4	5	9	3	4	7	2	4	6	5	5	10	4	4	8	2	5	7	4	4	8	4	2	6	2	4	6
C	2	3	5	2	7	9	4	3	7	4	2	6	0	4	4	2	2	4	4	3	7	3	7	10	6	3	9
D	7	3	10	5	5	10	4	0	4	9	2	11	6	1	7	4	0	4	7	3	10	6	5	11	3	0	3
E	3	9	12	2	6	8	6	13	19	0	0	0	0	0	0	0	0	0	16	7	23	19	9	28	20	4	24

## Key (Grade 8)

A	Those of Cells	B	Those of Separating techniques	C	Those of Electricity
D	No preference				

## Key (Grade 9)

A	Those of Microbes and Disease	B	Those of Atoms and Elements	C	Those of Light
D	No preference				

## Key (Grades 10 to 12)

A	Those of Biology	B	Those of Chemistry	C	Those of Physics
D	No preference	E	Only study one Science subject		

5.26b

Percentages

Question : Which Science subject practicals do you prefer?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	15.2	23.3	19.1	20.8	35.7	26.3	4.4	19.3	11.2	20.6	18.2	19.4	20.3	29.6	24.4				20.0	20.5	20.3	21.7	35.9	28.2	9.6	15.0	11.6
B	8.7	32.6	20.2	10.4	10.7	10.5	19.1	24.6	21.6	16.2	15.2	15.7	8.7	24.1	15.4				16.4	16.7	16.5	23.9	35.9	29.4	9.6	16.7	12.2
C	58.7	16.3	38.2	22.9	14.3	19.7	14.7	14.0	14.4	7.4	27.3	17.2	17.4	14.8	16.3				14.5	16.7	15.8	13.0	20.5	16.5	12.5	21.7	15.9
D	17.4	27.9	22.5	45.8	39.3	43.4	33.8	14.0	24.8	25.0	16.7	20.9	15.9	0.0	8.9				29.1	10.3	18.0	41.3	7.7	25.9	15.4	13.3	14.6
E							27.9	28.1	28.0	30.9	22.7	26.9	37.7	31.5	35.0				20.0	35.9	29.3	0.0	0.0	0.0	52.9	33.3	45.7

	Biology									Chemistry									Physics								
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	5.9	20.0	14.3	29.4	18.5	22.7	23.8	23.1	23.4	5.3	30.8	15.6	28.6	30.8	29.6	38.5	46.2	42.3	3.1	10.5	5.9	13.5	11.5	12.7	11.4	26.7	16.0
B	23.5	20.0	21.4	17.6	14.8	15.9	9.5	15.4	12.8	26.3	38.5	31.3	28.6	30.8	29.6	15.4	38.5	26.9	12.5	21.1	15.7	10.8	7.7	9.5	5.7	26.7	12.0
C	11.8	12.0	11.9	11.8	25.9	20.5	19.0	11.5	14.9	21.1	15.4	18.8	0.0	30.8	14.8	15.4	15.4	15.4	12.5	15.8	13.7	8.1	26.9	15.9	17.1	20.0	18.0
D	41.2	12.0	23.8	29.4	18.5	22.7	19.0	0.0	8.5	47.4	15.4	34.4	42.9	7.7	25.9	30.8	0.0	15.4	21.9	15.8	19.6	16.2	19.2	17.5	8.6	0.0	6.0
E	17.6	36.0	28.6	11.8	22.2	18.2	28.6	50.0	40.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	36.8	45.1	51.4	34.6	44.4	57.1	26.7	48.0

## Key (Grade 8)

A	Those of Cells	B	Those of Separating techniques	C	Those of Electricity
D	No Preference				

## Key (Grade 9)

A	Those of Microbes and Disease	B	Those of Atoms and Elements	C	Those of Light
D	No Preference				

## Key (Grades 10 to 12)

A	Those of Biology	B	Those of Chemistry	C	Those of Physics
D	No Preference	E	Only study one Science subject		

5.27a

Values

Question : Do you feel like a real scientist when doing practicals?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	23	26	49	19	15	34	24	27	51	33	31	64	15	20	35	42	41	83	20	34	54	18	21	39	34	23	57		
B	22	10	32	28	12	40	40	32	72	35	35	70	49	34	83	50	22	72	35	46	81	25	18	43	64	37	101		

	Biology									Chemistry									Physics										
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12				
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
A	5	14	19	11	11	22	4	9	13	5	5	10	9	9	18	4	7	11	14	8	22	13	11	24	7	4	11		
B	13	13	26	6	16	22	16	17	33	12	8	20	5	4	9	8	6	14	15	11	26	24	15	39	25	11	36		

Key

A Yes

B No

5.27b

Percentages

Question : Do you feel like a real scientist when doing practicals?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	51.1	72.2	60.5	40.4	55.6	45.9	37.5	45.8	41.5	48.5	47.0	47.8	23.4	37.0	29.7	45.7	65.1	53.5	36.4	42.5	40.0	41.9	53.8	47.6	34.7	38.3	36.1			
B	48.9	27.8	39.5	59.6	44.4	54.1	62.5	54.2	58.5	51.5	53.0	52.2	76.6	63.0	70.3	54.3	34.9	46.5	63.6	57.5	60.0	58.1	46.2	52.4	65.3	61.7	63.9			

	Biology						Chemistry						Physics																	
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	27.8	51.9	42.2	64.7	40.7	50.0	20.0	34.6	28.3	29.4	38.5	33.3	64.3	69.2	66.7	33.3	53.8	44.0	48.3	42.1	45.8	35.1	42.3	38.1	21.9	26.7	23.4			
B	72.2	48.1	57.8	35.3	59.3	50.0	80.0	65.4	71.7	70.6	61.5	66.7	35.7	30.8	33.3	66.7	46.2	56.0	51.7	57.9	54.2	64.9	57.7	61.9	78.1	73.3	76.6			

Key

A Yes

B No

5.28a

Values

Question : Should the practical be carried out individually, in pairs or in groups?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	6	5	11	8	2	10	3	5	8	15	5	20	7	5	12	14	7	21	7	6	13	5	2	7	13	7	20			
B	22	25	47	24	19	43	36	21	57	26	35	61	35	31	66	46	44	90	26	42	68	22	19	41	49	26	75			
C	19	10	29	16	9	25	27	33	60	28	28	56	24	20	44	35	19	54	23	34	57	16	18	34	40	29	69			

	Biology						Chemistry						Physics																	
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	1	3	4	3	3	4	3	2	5	0	0	0	4	1	5	1	1	2	2	2	4	8	3	11	3	2	5			
B	8	10	18	6	17	23	12	15	27	9	4	13	5	6	11	8	9	17	19	7	26	15	12	27	15	7	22			
C	9	14	23	8	10	18	6	10	16	8	9	17	5	6	11	3	3	6	10	10	20	15	12	27	15	7	22			

Key

A Individually

B Pairs

C Groups

5.28b

Percentages

Question : Should the practical be carried out individually, in pairs or in groups?

	Grade 8			Grade 9			Grade 10			Grade 11			Grade 12			Science			Biology			Chemistry			Physics					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	12.8	12.5	12.6	16.7	6.7	12.8	4.5	8.5	6.4	21.7	7.4	14.6	10.6	8.9	9.8	14.7	10.0	12.7	12.5	7.3	9.4	11.6	5.1	8.5	12.7	11.3	12.2			
B	46.8	62.5	54.0	50.0	63.3	55.1	54.5	35.6	45.6	37.7	51.5	44.5	53.0	55.4	54.1	48.4	62.9	54.5	46.4	51.2	49.3	51.2	48.7	50.0	48.0	41.9	45.7			
C	40.4	25.0	33.3	33.3	30.0	32.1	40.9	55.9	48.0	40.6	41.2	40.9	36.4	35.7	36.1	36.8	27.1	32.7	41.1	41.5	41.3	37.2	46.2	41.5	39.2	46.8	42.1			

	Biology									Chemistry									Physics											
	Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12			Grade 10			Grade 11			Grade 12					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
A	5.6	11.1	8.9	17.6	3.5	8.9	14.3	7.4	10.4	0.0	0.0	0.0	28.6	7.7	18.5	8.3	7.7	8.0	6.5	10.5	8.0	21.1	11.1	16.9	9.1	12.5	10.2			
B	44.4	37.0	40.0	35.3	60.7	51.1	57.1	55.6	56.3	52.9	30.8	43.3	35.7	46.2	40.7	66.7	69.2	68.0	61.3	36.8	52.0	39.5	44.4	41.5	45.5	43.8	44.9			
C	50.0	51.9	51.1	47.1	35.7	40.0	28.6	37.0	33.3	47.1	69.2	56.7	35.7	46.2	40.7	25.0	23.1	24.0	32.3	52.6	40.0	39.5	44.4	41.5	45.5	43.8	44.9			

Key

A Individually

B Pairs

C Groups

**Appendix 6**  
Practical Handout

---

**AN INVESTIGATION INTO THE OSMOSIS OF POTATO CELLS**

**Date:** .....

**Introduction:** Osmosis occurs when a selectively permeable membrane hinders the flow of molecules across it thus, not allowing them to be evenly distributed. This results in water flowing from a high water potential to a low water potential until it is evenly distributed (i.e., from a dilute solution to a concentrated solution). Therefore, *osmosis is the net flow of water through a semi permeable membrane to become evenly distributed.*

**Aim:** What is the purpose of this investigation?

To investigate osmosis in potato cells.

**Hypothesis:** Suggest a hypothesis being tested in this activity.

.....  
 ..... [1]

**Apparatus and Materials:**

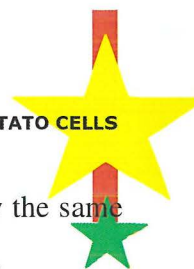
- |                                 |  |
|---------------------------------|--|
| Petri dishes                    | Potatoes   |
| Ruler                           | Distilled water  |
| Balance (to two decimal places) | Five different concentrations of salt solution (0.5%, 1%, 2%, 5%, and 10%) |
| Cork borer                      |  |
| Chopping board                  |  |
| Labels                          |  |
| Tissue paper                    |  |

**Fair Testing:**

The variables needed to be kept the same during this experiment to make it a fair test are:

1. ....
2. ....
3. ....

[3]



**Method:**

1. Using a cork borer and a chopping board cut 15 pieces of potato roughly the same size. Make sure that no holes are present and that any dead skin is cut off.
2. Weigh and measure the length of each piece of potato and make a note of the concentration it is going into (individual pieces of potato can be distinguished using a labelled toothpick). Also note the appearance of the cylinder.
3. Fill 5 Petri dishes with the 5 solutions and carefully label them. Put 3 pieces of potato in each of the Petri dishes.
4. Leave for about 45 minutes so that osmosis can occur. After the period of time take out the pieces of potato from each solution one at a time and blot the excess water with tissue paper.
5. Note the appearance of each cylinder and weigh and measure the length of each piece of potato, write down the result noting what the weight and length was and what solution it came from. Repeat this for all 15 pieces.
6. Work out the difference in mass and length of each potato before and after it was placed in the solution. Using the answers obtained work out the percentage change of the potatoes.

**Diagram:** Draw an appropriately labelled diagram of the set up.

[2]

**Precautions:** List two precautions.

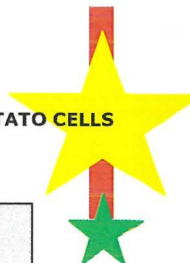
1. ....
2. ....

[2]

**Sources of Error:** List two sources of error.

1. ....
2. ....

[2]



Results:

*Changes in appearance of potato cylinder*

Percentage of NaCl solution (%)	Appearance of cylinder
0.0	
0.5	
1.0	
2.0	
5.0	
10.0	

[3]

*Changes in length of the potato cylinders*

Percentage of NaCl solution (%)	0	0.5	1	2	5	10
Initial length (cm)						
Final length (cm)						
Change in length (cm)						
Percentage change in length (%)						

[6]

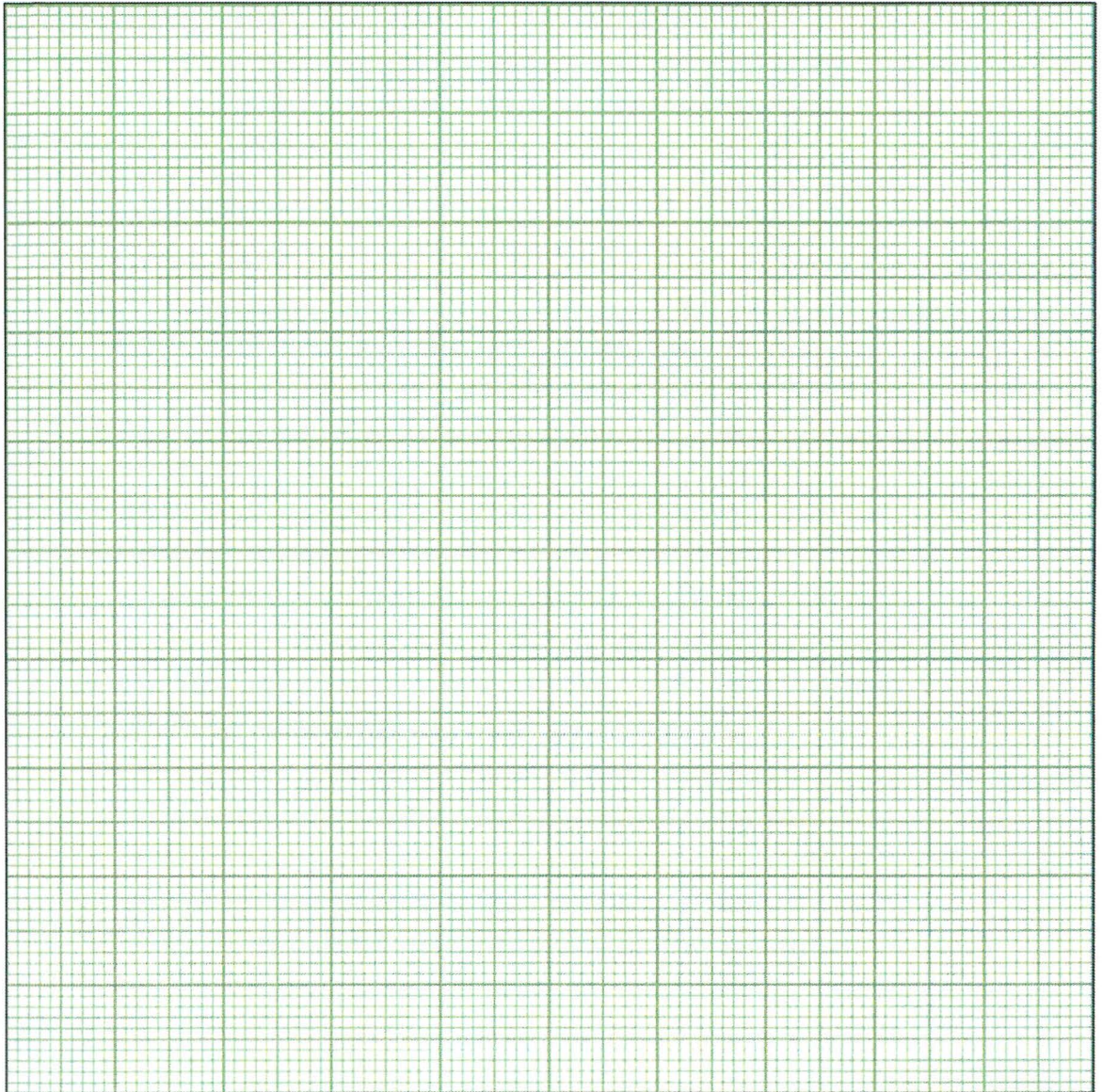
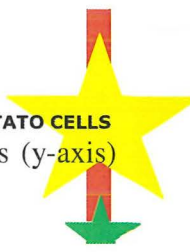
*Changes in mass of the potato cylinders*

Percentage of NaCl solution (%)	0	0.5	1	2	5	10
Initial mass (g)						
Final mass (g)						
Change in mass (g)						
Percentage change in mass (%)						

[6]

**AN INVESTIGATION INTO THE OSMOSIS OF POTATO CELLS**

On the graph paper below, draw a graph illustrating Percentage change in mass (y-axis) and Percentages of NaCl solution (x-axis).



[5]

**Discussion:**

1. Which of the beakers contained solutions that were:

- less concentrated than the solution in the cells;

.....

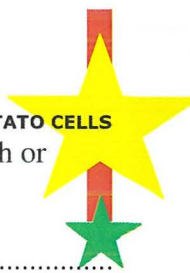
- more concentrated than the solution in the cells;

.....

- about the same concentration as the solution in the cells?

.....

[3]



2. Which way is the most accurate for recording the results – measuring length or weighing? Give a reason.

.....  
[1]

**Conclusion:** Use your knowledge of osmosis and cell membranes together with the observations made in this activity to explain what has occurred in the potato cells in each of the sample solutions. Use diagrams to complement your explanations.

1. 0% NaCl solution: .....

.....

.....

2. 0.5% NaCl solution: .....

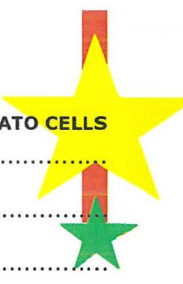
.....

.....

3. 1% NaCl solution: .....

.....

.....



4. 2% NaCl solution: .....

.....

.....

5. 5% NaCl solution: .....

.....

.....

6. 10% NaCl solution: .....

.....

.....

[12]

**Evaluation:**

Outline two limitations related to this experiment.

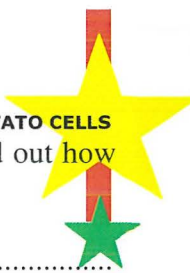
1. ....
2. ....

[2]

What can be done to reduce these limitations?

1. ....
2. ....

[2]



**Extension:** How could you extend your work by testing another variable to find out how osmosis affects the mass of a potato chip?

.....

.....

[1]

[Total 41 marks]

**Handling of laboratory apparatus:**

Skill	Maximum marks (2 marks)
Using cork borer	
Correctly labelling Petri Dishes	
Correct weighing procedure	
Correct measuring procedure	
Safety conscious	

[Total 10 marks]

<b>Grand Total</b> (out of 51)	
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<b>Teachers' comments</b>	
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## **Appendix 7**

### **Assessment Criteria for Science Practical Work**

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### Assessment Criteria for Science Practical Work

When marking practical work for Science subjects, teachers should follow the criteria set out below. Each experiment is to carry a maximum of 51 marks. Marks are to be awarded according to how closely the student satisfies the criteria indicated. Students are to be given a copy of these criteria.

Criterion	3	2	1	0
<b>Introduction</b> Briefly outline the theory behind the experiment. What do you think will happen?	Includes detailed, clear and relevant information. Includes prediction.	Includes relevant information but is incomplete and/or unclear. No or inappropriate prediction.	Attempted with little relevant information. No prediction.	Not done
<b>Aim(s)</b> Describe what you are trying to find out.	Clear description, good structure.	Acceptable description and structure.	Unclear and/or poor structure.	Not done
<b>Hypothesis</b> State what you expect to happen.	A suitable hypothesis drawn.	Acceptable hypothesis drawn.	Unclear and/or poor hypothesis drawn.	Not done
<b>Materials and Apparatus</b> List all apparatus and materials that you used.	Appropriate materials and apparatus used, thorough listing.	Acceptable materials and apparatus used, but limited.	Poor listing of materials and apparatus used.	Not done
<b>Fair Testing</b> List the variables that need to be kept constant during the experiment.	Suitable listing of variables.	Acceptable listing of variables.	Poor listing of variables.	Not done
<b>Method</b> List everything you did, in order and in the correct tense.	Appropriate methodology well ordered and thorough. Correct tense.	Acceptable methodology – acceptable order and completeness and/or incorrect tense.	Weak methodology – poor order, missing parts. Incorrect tense.	Not done
<b>Diagram</b> Draw a well-labelled diagram using the correct stationery such as science stencil, pencil and ruler.	Diagram is clear and well labelled.	Acceptably drawn diagram with some incorrect labelling.	Poor diagram with incorrect labelling.	Not done

<b>Precautions</b>	Correctly identifies a number of precautions needed to be taken when carrying out the experiment.	Identifies some of the precautions taken in the experiment.	Little attempt to list precautions.	Not done
<b>Sources of Error</b>	Correctly identifies sources of error.	Identifies some sources of error.	Little attempt to list some sources of error.	Not done
<b>Results</b> Record your results systematically and include everything you found out. Include graphs, table, photos etc. to help show your results.	Systematic, comprehensive and includes a good range of appropriate presentation methods. Excellent quality of information/ data.	Acceptable recording and quality of information/ data. Limited range of presentation methods.	Little attempt to use a range of presentation methods. Some inappropriate or incorrect information/ data.	Not done
<b>Discussion</b> Discuss your results.	Excellent discussion of results.	Acceptable discussion of results.	Limited discussions of results.	Not done
<b>Conclusion</b> List the main things you have discovered or found out from your results.	Excellent conclusion drawn.	Acceptable conclusion drawn.	Limited conclusion drawn.	Not done
<b>Evaluation</b> Outline the limitations related to the experiment. Suggest what can be done to reduce these limitations.	Correct identification of the limitations of the experiment. Suitable suggestions for improvement.	Adequate identification of the limitations of the experiment. Limited attempt at suggestions for improvement.	Poor identification of the limitations of the experiment. Few or no suggestions for improvement.	Not done
<b>Extension</b> Suggest how you can extend your work by testing another variable.	Excellent suggestion for an extension.	Acceptable suggestion for an extension.	Poor suggestion for an extension.	Not done
<b>Overall presentation</b> Report is clearly presented	Clear and logical report.	Moderately clear and logical.	Poor clarity and logic.	Not done

<b>Acknowledgements and references</b> List any books or websites you used.	Complete and correctly referenced.	Complete with some incorrect referencing; or correctly referenced but incomplete.	Incomplete or incorrectly referenced.	Not done
<b>Skills</b> This assesses how well you performed the experiment	Handles all apparatus properly. Is proficient in the skills required.	Handles some apparatus properly. Is capable of using the skills required but needs more practice.	Handles only the most basic apparatus. Limited skills displayed.	Not done