

**THE INFLUENCE OF PRACTICAL WORK ASSESSMENT METHOD IN DEVELOPING  
PRACTICAL WORK SKILLS OF ADVANCED LEVEL PHYSICS STUDENTS IN  
ZIMBABWE**

by

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## **DECLARATION**

**I declare that the thesis with the title: *The influence of practical work assessment method in developing practical work skills of Advanced Level physics students in Zimbabwe, is my own work and that all the sources used or quoted have been cited and acknowledged by means of complete references.***

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SIGNATURE

(Mr)

03 May 2016

DATE

## **DEDICATION**

In memory of my beloved father the late Richard Saileck Zezekwa

## **ACKNOWLEDGEMENTS**

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## **LIST OF ABBREVIATIONS**

A level	Advanced level
AQA	Assessment and Qualification Alliance
BEAR	Berkley Evaluation and Assessment Research Centre
CFA	Classroom Formative Assessment
DAPS	Direct Assessment of Practical Work skills
EDXCEL	Education and Excellence
FGD	Focus Group Discussion
GCE	General Certificate in Education
GCSE	General Certificate in Secondary Education
IAPS	Indirect Assessment of Practical Work Skills
IFA	Interactive Formative Assessment
MOE	Ministry of Education
OCR	Oxford, Cambridge and RSA Examination Board
PSV	Practical Skills Verification
PWA	Practical Work Assessment
SBA	School Based Assessment
SCORE	Science Community Representing Education
STEM	Science Technology Engineering and Mathematics
TAPS	Techniques for Assessment of Practical Skills in Science
UNICEF	United Nations International Children's Emergency Fund
UNISA	University of South Africa
Zimsec	Zimbabwe Schools Examination Council

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## **ABSTRACT**

Practical work plays an important role in the teaching and learning of science. This study was conducted to determine whether the methods and practices employed by physics teachers in Zimbabwe - as required by the Zimbabwe School Examination Council (Zimsec) ‘A’ Level Physics Syllabus (9188) on the assessment of practical work skills assist the students in developing other crucial practical skills like manipulation, observational, planning and designing apart from presentation and analysis skills. The convergent parallel mixed methods approach of Creswell (2014) was used to collect, present and analyse data. Quantitative data were collected using the structured observation schedule to get assessment marks for a student using both methods of indirect assessment of practical work skills (IAPS) and direct assessment of practical work skills DAPS for the same practical work activity. Qualitative data were obtained from interviews with the physics teachers and Focus Group Discussion (FGD) with the ‘A’ level physics students.

Pearson’s correlation coefficient ( $r$ ) of the percentage rating of marks obtained by the student as observed during practical work sessions compared to the obtained mark from the submitted practical work report for the same practical work activity was calculated and found to be 0.135 with a P- value of 0.432. Both the narrative approach (Creswell, 2007) and conservation analyses (Gray, 2011) were used to present and analyse data from focus group discussions with ‘A’ level physics students and interviews with the physics teachers.

The major finding from the analysis of quantitative data was that there was no association between the grades obtained by the student from DAPS as compared to IAPS for the same practical work activity as the value of  $r$  was found to be very low. This implied that passing practical work through the assessment of practical work report did not necessarily mean that the student could have mastered the basic skills of manipulation, designing, observation and planning. The views of physics teachers and students who participated in the study were that, the current method of practical work assessment used by Zimsec is not relevant in encouraging students to develop a variety of practical work skills as students concentrated on mastering presentation and analysis skills in order to pass practical work examinations. The study recommends that an alternative model of practical work assessment that integrates both DAPS and IAPS should be used to ensure valid and reliable assessment of practical work skills of ‘A’ level physics students.

## **KEY TERMS**

Advanced Level

Assessment

Direct Assessment of Practical Work Skills

Examination Boards

Indirect Assessment of Practical Work Skills

Mixed Methods Approach

Physics Curriculum

Physics Practical Work

Practical Work Skills

## **CHAPTER ONE**

### **INTRODUCTION**

#### **1.1 Purpose of the study**

The purpose of this study is to get insight on practical work skills that are developed by Advanced Level ('A'- Level) physics students in Zimbabwe during their two year high school course before such students could be enrolled for tertiary education. This study is based on the assumption that, the way in which 'A' level physics practical work is being assessed in Zimbabwe has had influence on the type of practical work skills that are developed and mastered by students. It is the assessment method that influences how practical work in science is taught and done (Abrahams and Millar, 2008; Abrahams and Saglam, 2010 and Abrahams and Reiss, 2012). The thrust is to observe whether the methods and practices that are employed by physics teachers as dictated by the Zimbabwe School Examination Council (Zimsec) 'A' Level Physics Syllabus (9188) on the assessment of practical work of students will assist the students in developing other crucial practical skills like manipulation, observational and designing apart from presentation and analysis skills. Notwithstanding the importance of presentation and analysis skills, other practical skills are crucial to an 'A' level physics student at destinations beyond the 'A' level physics laboratory.

Practical work plays an important role in the teaching and learning of science. As Millar (2004:4) postulates, practical work helps students to understand how scientists work. Learning needs to be contextualised to produce desirable results. If, and when well planned and effectively implemented, practical work situates students' learning in varying levels of inquiry where the students are both mentally and physically engaged (Lunetta, Hofstein and Clough, 2007:394). The rationale for practical work according to Dillon (2008:30) includes cognitive development of learners, skills development (manipulation, observation, measurement, prediction and inference), motivating learners, and promoting scientific methods of thought and to elucidate theoretical work so as to aid learner comprehension. In addition, practical work also provides a training tool for students – especially in problem solving. This assertion could be corroborated by the postulation made by Stacey and Spielman (2014:8) who argued that experiments were in fact the essence of science, for studying science without practical work would be tantamount to studying literature without books. These are but some of the highlights on the importance of practical work in science teaching and learning – especially in physics; hence the need to assess practical work in a way that will bring the best results of students' capabilities.

The way in which practical work is assessed in high schools has a major bearing on the development of practical skills such as equipment manipulation, observation and designing. Mathews and McKenna (2005) and Kennedy and Bennett (2005) submit that assessment of practical work in physics has continuously been a problem. It is important to determine useful skills relevant for real life which students would have to acquire. Reiss, Abrahams and Sharpe (2012:4) argue that whilst practical skills in science are clearly valued and often referred to within literature, what has become evident is that there is lack of clarity as to what these skills actually are and how they might, most effectively, be validly assessed. Practical work is an important aspect of physics and its assessment should reflect this importance.

Buick (2010:13) emphasises that when assessing practical work, it is important to assess skills rather than knowledge. The assessment of students' practical work tends to narrow the number of skills which students are assessed on, from the observations by Dillon (2008:42). This scenario is often observed if summative assessment of practical work is employed. Dillon (2008:42) furthermore notes that the other challenge facing physics teachers is the difficulty in assessing the impact of practical work on students. In fact, it is widely affirmed that the assessment of students' practical work in science has always been problematic. A review on the assessment of practical work found that some countries that are counted as high performing, particularly in science make use of substantial portion of direct assessment of practical skills when compared to countries such as Australia, England and Scotland for instance who rely mainly on indirect assessment (Abrahams, Reiss and Sharpe, 2013:224).

Post-independence and liberation from British rule, the new Zimbabwean government adopted the British education system. It is a known fact that the British education system in pre-independence and liberation Zimbabwe was highly academic. This suggests therefore that the education system of the British in pre-independence and liberation Zimbabwe had little emphasis on real life skills. Therefore, the newly adopted 'A' level post-independence Zimbabwe physics syllabus was no different from the pre-independence and liberation Zimbabwean syllabus. The Zimsec 'A'- level Physics syllabus adopted an Indirect Assessment of Practical Work Skills (IAPS) where at the end of a two year course students would sit for a two and half hour practical work examination. The assessment is based on the submitted practical work report where other skills are inferred from the accuracy of the obtained values by the candidate. Zimsec mainly tests how well students have planned a practical investigation and analysed results but students' abilities to manipulate equipment are not directly observed or assessed. Assessment is considered one of the most powerful influences on what and how teachers taught and what and how learners learnt (Gopal and Stears, 2007:16).

Assessment drives teaching and learning so much such that science educators need to find ways of improving the current methods of conducting it. It is therefore imperative and necessary to design assessment techniques that would strike a balance between the affective and cognitive domains. There is variation among awarding boards in their approach to assessing practical work in science with arguments mainly centred between whether practical work should be assessed directly or indirectly. According to Reiss, Abrahams and Sharpe (2012:4), practical skills can be assessed by the Direct Assessment of Practical Skills (DAPS) - say when a teacher observes and assesses a student carrying out an experiment, or the Indirect Assessment of Practical Skills (IAPS), for example when a teacher assesses a report written by a student who has done the experiment.

It has been widely observed and concluded that some teachers – especially in science only teach to prepare the students for examinations. Suggestively, such teachers failed to develop their pupils' real-life skills. Students from this kind of teaching and learning environment would lack proper attitudinal preparation which would assist them when confronted with real-life challenges – for example, livelihood generation among others. Gopal and Stears (2007:17) argue that all learning outcomes cannot readily be tapped through tests alone as a means of assessment. Roberts and Gott (2004:20) affirmed this assertion. In fact, Roberts and Gott (2004:20) noted that students have to be engaged in the process that scientists use to construct and apply knowledge. Based on this postulation, student assessment has therefore to be consequently designed and conducted on activities done by the students than report. Practical work test reports cannot completely be used to assess the complex competencies expected of a pupil when carrying out practical work activities in a practical examination as observed by Shay and Jawitz (2005:105). This argument is supported by Sentamu-Namubiru (2010:311) who opined that learner diversity requires the implementation of various assessment strategies as different learners may demonstrate the achievement of different outcomes in a variety of ways. Awarding bodies and stakeholders should consider carefully the optimum balance between the direct and indirect assessment of practical work in science from the observations by Reiss, Abrahams and Sharpe (2012:5).

This study thus thrives at finding out the influence of practical work assessment method in developing practical work skills of Advanced Level physics students in Zimbabwe. This is done at the hindsight that such assessment is based on the submitted practical work report where skills such as designing, observation and manipulation among many others are inferred from the correctness of the values obtained by the candidate during practical work examination. The study therefore wants to test the assumption by examiners that if a student obtains correct practical work results, it means that such student might have mastered all the important practical work skills expected of an 'A' –level physics

graduate. Basing on the obtained results of the study an alternative model of assessing ‘A’ –level physics practical work will be proposed.

## 1.2 Context of the study

In Zimbabwe, students who pursue a two year advanced level (‘A’-Level) physics curriculum are expected to write a two and half hour practical work examination at the end of the study. This examination is in fact in addition to similar examination on theory which takes approximately four hours. This examination is set by the Zimbabwe School Examination Council (Zimsec) - a board responsible for examining candidates at both primary and secondary school levels. According to the requirements of the ‘A’ level physics syllabus (9188), the students should sit for practical work examination. At the end of the examination, the students are expected to produce a practical work report. The assessment is based on the submitted practical work report. During this examination, students are expected to do a total of three practical work activities. The activities are in mechanics, electricity and one design practical developed from any other section of the syllabus. As a way of preparing students for the final practical work examination during the two year course, students are normally exposed to do practical tests every week or fortnightly. The practical sessions are done under the guidance of a technician with minimum help from the physics teacher. The physics teacher normally will be interested in marking the submitted final report without much to do with the processes of doing the practical work. It is against this background that the researcher would like to find out the implications of such a system in developing other practical work skills to ‘A’ level physics students apart from presentation skills. For the purpose of this study the other skills which students are expected to develop will be broadly categorised under manipulation, observation and designing.

Those involved in determining how school science practical work is assessed in any country should learn lessons from how it is assessed in other countries as well as how it is assessed from other subjects. Observations by the researcher during the period of teaching ‘A’ level physics indicate to the fact that, students often are cornered to concentrate on developing and mastering their presentation skills. These are skills which are necessary for the students to pass the final external examination. Sadly, students cannot ignore to concentrate on such skills as dictated by the requirements of the system. The art of carrying out practical work activities is also important as this may translate to the development of other important skills such as designing, manipulation and observation. This study is motivated by the realization that most of the ‘A’ level physics graduates lack such skills as setting up circuits, taking an accurate reading or designing a practical when they enter university or other destinations beyond the ‘A’ level physics laboratory, despite passing ‘A’ level physics practical examination. An examination board must design a qualification which gives a reliable indication of knowledge, skills and understanding of the person on which it confers its qualification. During post-

independence and liberation Zimbabwe, alternative assessment strategies have become an important part of the debate regarding the reform and restructuring of the science education system.

### **1.2.1 The context of the ‘A’ Level Physics curriculum (Syllabus 9188)**

According to the syllabus (9188) document produced by Zimsec, the major aims of the Advanced level physics curriculum are to:

- Provide, through well designed studies of experimental and practical science, a worthwhile educational experience for all students to recognise the usefulness and limitations of scientific method and appreciate its applicability,
- develop abilities and skills that are relevant and practice of science beyond ‘A’ level physics, and
- Finally develop attitudes relevant to science such as objectivity and skills inquiry among physics students.

The assessment objectives as outlined in the physics syllabus cover broad areas on:

- Knowledge and understanding of phenomena, scientific and technological applications, laws, definitions and theories,
- Handling, applying and evaluating information to include manipulation of numerical and other data, and
- Experimental skills and investigations to include interpretation and evaluation of observations and experimental data accurately and precisely, measurement methods and techniques.

To achieve these objectives candidates will be expected to sit for five papers as indicated in table 1.1.

Table 1.1 Paper Structure

Paper	Type of paper	Duration	Marks
1	Multiple choice	1hr	40
2	Structured Questions	1hr 15min	60
3	Free response questions	50 min	40
4	Practical	2hrs 30 min	50
5	Free response questions	1hr 15min	60

The skill weighting and distribution is also indicated in table 1.2.

Table 1.2 Skill weighting and distribution

Skill	Paper1		Paper 2		Paper 3		Paper 4		Paper 5		Subject weighting
	M	W%	M	W%	M	W%	M	W%	M	W%	
<b>1.Factual recall and comprehension</b>	20	50	20	33	12	30	5	10	18	30	<b>30</b>
<b>2.Handling and Application</b>	15	37.5	30	50	16	40	25	50	24	40	<b>44</b>
<b>3.Deductive Reasoning and Synthesis</b>	5	13.5	10	17	12	30	20	40	18	30	<b>26</b>
<b>Total</b>	40	100	60	100	40	100	50	100	60	100	100

**Legend:** M- Mark allocated W- Skill weighting per paper

Practical work only contributes less than twenty percent of the total marks as indicated in tables 1.1 and 1.2 respectively. Downs (2013:1) however warns that practical work is a core skill in science such that proposals which would allow pupils to fail their practical assessment and still achieve excellent grades in science are unacceptable. Though the issue of weighting is not necessarily the focus of this study, it is difficult to ignore such an observation considering the structure of the physics examination papers in particular and those of Advanced Level sciences in general pertaining percentage weighting of practical work in the final assessment.

### **1.2.2 Practical Work Assessment: Major marking points on an ‘A’ level physics practical work report**

According to the ‘A’ level physics syllabus (9188) on page 35, marks are awarded basically for correct tabulation of results, graphical work and analysis of results at the expense of skills such as planning, manipulation and observation among many others. The researcher would like to explain in detail how practical work is marked guided by the requirements and expectations from the Zimsec ‘A’ level physics syllabus (9188). This is critically important and fundamental to determine whether the basis of practical work assessment as outlined in the syllabus will assist students to develop other practical work skills that are required by students in environments beyond the ‘A ‘level’ physics laboratory apart from the presentation and analysis skills. Three areas of presentation of results, graphical work and analysis of results will be considered. Expectations on the necessary skills

required to tackle the design question will also be explained as guided by the ‘A’ level physics syllabus (9188).

According to the syllabus about eight out of twenty marks normally allocated for a practical in either mechanics or electricity are awarded for correct presentation of data. The actual number of marks will vary from paper to paper with normally a variation of not more than two marks. Candidates are expected to take a suitable number of readings over a specified range. Marks are awarded for taking repeated readings for example in timing of oscillations. Where candidates are expected to do some calculations from raw data, calculations derived from raw readings should be correct and given to appropriate number of significant figures governed by the number of significant figures in the raw data. In other words, the number of significant figures in the calculated values should equal the number of significant figures in the raw data. Marks are also awarded for this ability to maintain the number of significant figures in calculated values as with the raw data.

Neat presentation of data is expected if candidates are to score high marks according to the Zimsec physics syllabus (9188). Numerical data and values should be presented in a single table. Marks are awarded for including columns for raw data and values calculated from them with the correct quantity and unit. An example given in the syllabus is that on current measurement where the column heading should be  $I/mA$  or  $I$  ( $A$ ) depending on the scale range of the measured quantity. Candidates are expected to use conventional symbols or abbreviations without further explanations. Candidates are also expected to give all recorded raw readings of a quantity to the same degree of accuracy if they are to score some marks on data presentation. Candidates are normally penalised if the degree of precision used is incompatible with the instrument used according to the requirements from the Zimsec physics syllabus (9188) as outlined on page 36. Marks are also given if candidates are able to give calculated quantities the same number of significant figures as the measured quantity of least accuracy.

It is interesting to note that if a candidate is able to meet the above requirements on data presentation as per Zimsec physics syllabus (9188) prescription even if the raw data obtained were not accurate, the candidate will still be in a position to score some marks. Thus from the marking scheme it follows that with good presentation skills a candidate can possibly pass without having mastered skills like observation, measuring and planning but through good reporting. Zimsec however argues that the mastery of other skills is inferred from the correctness of the results obtained. This however is not reflected on the marking guidelines of practical work report as outlined in the Zimsec physics syllabus (9188). This study will therefore want to establish whether the claim is true so that alternative methods of assessing practical work could be suggested in addition to those of the practical work tests.

Another section where candidates get about six marks out of twenty on an experiment in either mechanics or electricity is on graphical work. Candidates are expected to rearrange expressions in cases where straight line graphs are to be plotted. It is imperative therefore that candidates need to be familiar with appropriate mathematical processes for taking logarithms and dealing with exponential functions according to the requirements outlined in the Zimsec physics syllabus (9188). Marks are scored for clearly labelling graph axes with quantity and unit. The graph is expected to occupy at least half the grid in both y- and x-directions. Candidates are also expected to use convenient scales (for example 1, 2, 4 or 5 units to a 2 cm square) and have clear numerical labels at 2 cm interval on either axes. Candidates are credited for plotting correctly points on the grid and penalised for doing so on the white margin to the grid. Candidates are credited for plotting points to an accuracy of better than half a small (2mm) square finely plotted with a sharp pencil and are penalised for thick pencil dots. The line of best fit should show an even distribution of points on either side of the line along its whole length for a candidate to be credited. Candidates are penalised for drawing thick or kinked lines. Straight lines drawn where curves are expected will not gain any marks. When measuring gradient, the assessor should give credit to the learner if points on the line chosen for the calculation are sufficiently separated and accurately read. It is expected that the hypotenuse of the triangle for gradient calculations should be at least half the lengths of the candidate's line. Credit will be given to candidates if they are able to read the intercept to better than half a small square. Candidates should also be able to determine the intercept from a graph with a false origin.

Again, if candidates are able to do graphical work as per Zimsec prescription above even using inaccurate data, it is possible for the candidate to score some marks out of the about six allocated for this section. It means that without mastering skills like planning, measuring, observation and manipulation among many others but with good reporting skills, one may scratch a pass mark.

Another section where candidates get about six marks out of twenty on an experiment in either mechanics or electricity is on analysis of results using the results from the graph. Credit will be given for using the correct number of significant figures and the correct units where appropriate as outlined in the Zimsec physics syllabus (9188). Sadly only about four marks out of six in this section are awarded for accurately obtaining the values of the unknown from the gradient and intercept. Candidates are penalised for getting values which are out of range from those expected by the examiner. It must be noted at this point that only four marks out of a possible twenty for a particular experiment are awarded for accurately carrying out the experiment from a close analysis of marking points of an 'A' level physics practical work report in either mechanics or electricity. It remains to be seen from the results of this study whether the current methods which are being employed by Zimsec to assess physics practical work will assist students in developing other crucial practical work skills in

addition to good reporting as dictated by the requirements of the current Zimsec physics syllabus. It appears as if students' mastery of practical skills are greatly influenced by the method which is used to assess such skills then students are forced to perfect their presentation skills in order to pass examination at the expense of other crucial skills expected of them in environments beyond the 'A'-level physics laboratory.

### **1.3 Statement of the problem**

If students fail to develop key practical skills such as designing, equipment manipulation and investigation at high schools because of the current system of practical work assessment, then these students are likely to face problems when they enter university and other environments beyond the 'A' Level Physics Laboratory. The practical work skills exhibited by 'A' level physics graduates are poor and there are reasons for believing that inadequate assessment practices are one of the main contributory factor for this. This mismatch raises eyebrows as to whether the skills assessed in the 'A' Level Physics curriculum are adequately developed or that the focus is on presentation skills that are easy to assess. The research is based on the hypotheses that, development of practical work skills in physics is largely influenced by the way in which practical work is assessed.

### **1.4 Aims of the study**

The focus of this study is on two main issues, which are:

- To evaluate the influence of current physics practical work assessment method on skills development of 'A' level physics students.
- To come up with suggestions on alternative ways of assessing Physics Practical Work activities to enhance the development of other key skills such as manipulation, observation and designing.

### **1.5 Research questions**

This study is guided by the following research questions.

#### **1.5.1 Research question 1**

- How does practical work assessment method influence the development of practical work skills of 'A' -level physics students?

### **1.5.2 Sub-research questions**

- How do ‘A’- level physics teachers assess practical work skills of students during the course of their programme?
- How relevant are the assessment practices on students’ practical skills development?

### **1.5.3 Research Question 2**

- What are the possible alternatives to physics practical work examinations?

## **1.6 Significance of the study**

This study is quite significant to a number of stakeholders. Stakeholders such as tertiary institutions and industry expected to absorb these students after their high school studies are some of the potential beneficiaries. The study is also significant in the sense that it emphasises acquisition of practical experiences by the students than mere theoretical presentations of subject content. This will go a long way on how an improvement on the assessment of practical work can be realised instead of the current method which is highly summative. In light of the above study aim and research questions, this study proposes an adoption of a holistic approach to assessment of learner practical work based on an alternative model of scientific approach. In developing any model of assessment important questions need to be asked about the abilities that might be assessed, the best ways to assess these abilities and who should carry out the assessment (Kennedy and Bennett, 2005).

The study is guided by the conceptual framework of formative assessment of practical work as opposed to summative assessment as dictated by practical work tests. It tries to expose the benefits of formative assessment despite the problems of scarcity human resource, objectivity of the assessment and high costs .These are some of the reasons that are always cited by advocates of summative assessment of practical work as a basis for not practising formative assessment of practical work. Dufresene and Gerace (2004)’s argument that the rationale for formative assessment is to effectively monitor and influence development of students’ thinking process, inquiry skills, attitudes towards science and learning behaviours cannot be overlooked. Formative assessment of practical work maybe a panacea to the problem of lack of other skills like observation, manipulation and designing that are often exhibited by ‘A’ level graduands in environments beyond the ‘A’ level physics laboratory.

The study sought to focus on the competencies of ‘A’ level students on mastery of skills like observation, manipulation and designing as they carry out practical work activities and rated against the obtained mark on the submitted report as a way of finding out the value of practical tests in developing practical work skills by ‘A’ level physics students. Black and William (2004) and William

and Leahy (2007) concur that the major significance of formative assessment is to improve learning. This study in conclusion, will provide guidance on alternative ways of assessing practical work than the current administered practical work tests in Zimbabwe and beyond.

### **1.7 Delimitations of the study**

The research employed a case study approach. The subjects of the study were sixth form physics students and six physics teachers sampled from three high schools in Harare province in Zimbabwe. The study sought to focus on the competencies of ‘A’ level physics students on mastery of skills such as observation, manipulation and designing as they carry out practical work activities and rated against the obtained mark on the submitted report as a way of finding out the value of practical tests in developing practical work skills by ‘A’ level physics students.

Correlation analyses was used in data analysis where correlation coefficients obtained between marks awarded by physics teachers on the submitted practical report and an observational scale used by the researcher during practical sessions were compared. Open ended interviews were administered on the physics teachers to solicit their views on the way the physics practicals are assessed as per Zimsec requirements. Focus Group Discussions (FGD) were also employed on the ‘A’ level physics students to source for their views on the assessment of physics practical work. It was unnecessary to include school heads and heads of science departments in the study as they may not be experts in the field of study under observation.

### **1.8 Definition of terms**

- Practical Work**

Practical work refers to tasks in which students observe or manipulate real objects or materials. These are learning experiences in which students interact with materials to observe and understand the natural world.

- Practical skills**

Skills necessary for undertaking a non-written task, for example, reading an oscilloscope. Practical skills include individual’s competency in the manipulation of a particular piece of apparatus/equipment.

- Practical Tests**

In this study practical tests refer to the practical work activities performed by ‘A’- Level physics students normally once per fortnight under examination conditions during the course of their two year

study. The practical work activities are often supervised by laboratory assistants. At the end of each practical session, the candidate is expected to produce a practical work report which is then marked by the physics teacher from which other practical skills of the candidate are inferred.

- **Assessment**

Assessment is a multifaceted term with varying dimensions such as, formative assessment which looks at progress, summative assessment which sums student's achievements and criterion referenced where students are assessed on the extent to which they have achieved set tasks without reference being made to achievement of other students. Assessment should also show some degree of reliability and validity. Whereas assessment entails provision of information (usually through testing), evaluation involves the making of judgements. Assessment in the context of this study refers to a variety of ways information is gathered, synthesised and interpreted on the practical work skills gained by students.

- **Zimbabwe Schools Examination Council (Zimsec)**

The board responsible for examining candidates at both primary and secondary school levels in Zimbabwe.

- **Advanced Level ('A'-Level)**

This means a two year high school course for students who would have successfully completed the Ordinary Level before such students could be enrolled for tertiary education in general and university education in particular. In their first year of 'A' level study the students will be in lower sixth form also referred to as Form Five and in their second year, the students will be doing upper sixth also referred to as Form Six. It is an academic qualification offered by Zimsec to students completing high school or pre-university education. In Zimbabwe this qualification require students to study any three subjects in science, arts or commercials. To be admitted for university education, one must have passed at least two 'A' level subjects.

- **Former Group A schools**

Before Zimbabwe gained independence in 1980 the education system was divided along racial lines and Group A schools were those schools reserved for white students with basically all resources for the teaching and learning process.

- **Former Group B schools**

Group B schools were those schools which catered for the education of the black majority usually with limited resources for learning.

- **Private school**

A school run by a board of trustees and normally caters for children from the elite class of the Zimbabwean society. The fees at these schools are high and resources for learning are found in abundance.

### **1.9 Assumptions**

The researcher assumed the following:

- Physics teachers mark practical work consistently and objectively.
- ‘A’ Level Physics teachers and students give honest answers during interviews.
- Research assistants are competent and professional.

### **1.10 Structure of the study.**

The study is divided into eight chapters as explained below:

- Chapter 1 outlines the background to the study including its purpose, context, significance, delimitation and assumptions. The statement of the problem as well as research questions are stated.
- Chapter 2 is about literature review. The study was guided by a theoretical framework on constructivism. Literature on the assessment of ‘A’ level physics practical work was reviewed. Literature on the assessment of practical work in other subjects was also considered. The chapter concludes by looking at lessons drawn from literature review.
- Chapter 3 is about the research methodology. The mixed methods approach was employed in this study. The convergent parallel mixed methods approach of Creswell (2014) was used to collect, present and analyse data. Data were collected using the observation schedule, interviews and focus group discussions. Issues on validity, reliability and ethics are also addressed.
- Chapter 4 is about the assessment of practical work skills of students from DAPS and IAPS. Chapter 4 presents and analyse quantitative data obtained from the assessment of students’ practical work skills using DAPS and IAPS.

- Chapter 5 is about teachers' views and practices on the assessment physics practical work skills. Chapter 5 deals with the qualitative aspects of this study with regards to data presentation, analysis and discussion.
- Chapter 6 is about students' views on the assessment of physics practical work skills. Chapter 6 deals with the qualitative aspects of this study with regards to data presentation, analysis and discussion.
- Chapter 7 is about an alternative model of practical work assessment. It outlines the model, its justification, challenges and proposed solutions.
- Chapter 8 looks at the conclusion and recommendations of the research study.

## **1.11 Chapter Summary**

This chapter basically shows the basis for carrying out this research, providing background information on the assessment of 'A' level physics practical work and how this assessment method influences the mastery of certain practical work skills by 'A' level physics students at the expense of others. The chapter starts by outlining the importance of practical work in science education in general and physics education in particular. It is necessary at this juncture to re-emphasise the assertion by Buick (2010:13) that when assessing practical work it is important to assess skills rather than acquired knowledge. The chapter also highlights why formative assessment of practical work is more important than summative assessment. This assertion is achieved by showing some advantages of Direct Assessment of Practical Work Skills (DAPS) as opposed to Indirect Assessment of Practical Work Skills (IAPS).

The second section of the chapter looks at the context of the study, highlighting the structure of the 'A' level physics curriculum in Zimbabwe. Practical work contributes about twenty percent of the total assessment. Aims and objectives of the 'A' level physics syllabus are also briefly stated. This chapter also details the current method of assessment of practical work as per Zimsec guidelines.

The third section of the chapter looks at the major marking points on an 'A' level physics practical work report in the three areas of data presentation, graphical work and analysis of results. From the analysis of the marking guide as outlined in the physics syllabus (9188), it is sad to note that only about a fifth of the total marks allocated for the assessment of practical work are on obtaining accurate values. Accurate values are values that are within the range of those that are expected by the examiner. A staggering four fifths of the marks are allocated for good data presentation and graphical work.

Firstly, this chapter outlines the statement of the problem, and later discusses the aims and research questions guiding the study. The research is being guided by the main research question: How does practical work assessment method influence the development of practical work skills of ‘A’ level physics students? This chapter also describes the significance of the study especially as it concerns the institutions that are expected to absorb the high school physics graduates this study refers to. In any study, the delimitation is important section in order to show the focus of a particular study as all problems that require investigation cannot be solved by one study. Key terms as used in this particular study were defined.

In conclusion this study thrives to find out whether the current methods used by Zimsec in the assessment of physics practical work will assist students to develop crucial practical work skills or only force them to concentrate on perfecting their presentation skills in order to produce a good report and eventually pass examination.

## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1 Introduction.**

This chapter presents the reviewed literature used for the purpose of this study. Literature review assists the researcher in understanding the problem, its context and its major components as well as stimulating the researcher to generalise own ideas based on other researchers' experiences. In addition, the review helps to identify and understand the theoretical perspective of the problem that is putting the research topic into its proper perspective. In the context of this study in particular, the purpose of the literature review was to get a global idea on the current assessment strategies employed by examination boards. Different forms and kinds of assessment including those related to formative and summative assessments are considered in this chapter in terms of Direct Assessment of Practical Work Skills (DAPS) and In-direct Assessment of Practical Work skills (IAPS) respectively. Emphasis on the assessment of practical work in England in this literature review was motivated by the fact that Zimbabwe adopted the Cambridge Advanced Level physics syllabus when she localised her examination which are now managed by Zimsec.

In this study on the influence of practical tests in developing practical work skills of 'A' level physics students, the assumption is that if practical work is done and assessed effectively, then students will be in a position to develop practical skills such as designing, equipment manipulation, observation and investigation in addition to presentation skills. It is therefore, important to assess these skills during practical sessions than relying on practical reports at the end of practical session ignoring the process of doing the practical work. The researcher wanted to find out whether 'A' level physics students develop important practical skills like manipulation, observation, designing and investigation if only practical reports are assessed in a summative way than formative assessment of such skills during practical sessions. These skills are crucial in environments beyond the 'A' level physics laboratory hence the need to make sure that students have developed them whilst they are still doing 'A' level.

In this section on literature review, the researcher will start by looking at the theoretical framework guiding the research study. The research is guided by the theoretical framework of constructivism. Issues on formative assessment and assessment in constructivism are also considered. This will be followed by literature on the assessment of 'A' level physics practical work and some perspectives on the assessment of practical work in science. This section will be concluded by considering literature on possible alternatives to physics practical examinations and lessons drawn from literature review.

## **2.2 Theoretical Framework**

The study is guided basically by the theoretical framework of constructivism. Thereafter formative assessment and assessment in constructivism will also be considered.

### **Constructivism**

Constructivism is seen as a theoretical framework on which most research into student thinking and learning is based. This is the reason why it is important to consider it when looking at the influence of practical work assessment method in developing practical work skills of ‘A’ level physics students. According to Jonassen and Landin (2002), constructivism is a theory of learning based on the idea that, knowledge is constructed by the knower based on mental activity. Porta and Keating (2008:81) present a different argument by purporting that things we perceive are rather a product of our conceptualisation thus constructivism is not a theory or an approach but a perspective. Human learning is constructed; it’s active rather than passive. Treagust and Duit (2008) argue that constructivist view primarily concerns a particular way of conceptualising knowledge and knowledge acquisition based on certain epistemology. The argument here is that, human knowledge is a process of personal cognitive construction or invention. Constructivism is more of a philosophy than a strategy. Treagust and Duit (2008) argue that constructivism has its roots in philosophy, sociology, psychology and education. Both psychological and epistemological principles of constructivism emphasise that knowledge cannot be separated from knowing the subject. The psychological principle emphasises the fact that students do not passively receive knowledge but built it. The epistemological principle asserts that the function of cognition is adaptive and enables students to construct viable explanations of experiences of the world. Both psychological and epistemological principles of constructivism emphasise that students need to be actively involved in building up their knowledge.

To fully appreciate the importance of constructivism as a learning theory, it is important to briefly consider the works of the originators of the theory of constructivism and its development to modern times. According to Driscoll (2005), the originators of the learning theory of constructivism are:

- John Dewey(1859-1952)
- Lev Semyonovich Vygotsky(1896-1934)
- Jean Piaget(1896-1980)
- Jerome Seymour Bruner (1915-2016)

According to Driscoll (2005), John Dewey is cited as the philosophical founder of constructivism. Dewey rejected the notion that schools should focus on repetitive, rote memorisation and proposed a method of learning where students would engage in real world, practical workshops in which they would demonstrate their knowledge through creativity and collaboration, Dewey (1916).Dewey

advocates for an active learner where students think for themselves and articulate their thoughts. According to Dewey (2016), progressive education should recognise the social aspect of learning and uses conservation and interaction with others. Dewey (1916) proposes a pragmatic approach to learning where the learner takes an active part. Constructivism was born from Dewey's theory of progressivism. Dewey argues that inquiry is a key part of constructive learning. Learning therefore consists of constructing meaning and constructing systems of meaning. Learning as a social activity also involves language.

Another founder of the constructivist learning theory is Vygotsky who proposes the social development theory. According Vygotsky (1980) social development theory argues that social interaction precedes development. Consciousness and cognition are the end products of socialisation and social behaviour. According to Vygotsky(1980), the theory is based on three themes that include, social interaction, the more knowledgeable other and the zone of proximal development. On social interaction, Vygotsky emphasizes the importance of language and culture in cognitive development. Vygotsky rejected the assumption made by Piaget that it was possible to separate learning from social context. Vygotsky(1980) demonstrated the importance of language in learning by demonstrating that in infants communication is a pre-requisite to the child's acquisition of concepts and language. According to Vygotsky(1980), during the process of learning, students participants begin a task with different understandings until they arrive at the shared understanding thereby creating a common ground for communication. Vygotsky used the term 'scaffolding' to refer to the support that is given to the learner during the learning process to fit the child's current level of performance through a shared endeavour between the expert and the less expert participant. According to Vygotsky the last level is the zone of proximal development where learners are given the opportunity to solve problems beyond their actual development level under adult guidance or in collaboration with more capable peers. Vygotsky's theory promotes learning contexts in which students play an active role in learning according to Driscoll (2005).

Jean Piaget proposed the theory of cognitive development. According to Piaget (1978), cognitive development has four distinct stages in children which are sensori motor, pre operational, concrete and formal. The sensori motor stage starts from birth up to the age of two years. At this stage Piaget (1978) argues that the infant is able to distinguish between itself and other objects. Learning at this stage takes place via assimilation. During the pre-operational stage of between two and four years, the child is not able to conceptualise abstractly and needs concrete physical situation. The third stage of concrete operation is reached at the age of between seven and eleven years. At this stage, the child begins to think abstractly and is able to conceptualise and create logical structures that explain physical experiences. The last stage according to Piaget (1978) is called the formal operations where the learner is capable of deductive and hypothetical reasoning.

According to Driscoll (2005), Piaget explained how new knowledge is shaped in order to fit with the learner's existing knowledge and how the existing knowledge can be modified to accommodate new knowledge. The major concepts in this cognitive process include assimilation, accommodation and equilibration. According to Driscoll (2005), Piaget explains that assimilation occurs when the learner perceives new objects or events in terms of existing schemas or operations. Accommodation occurs when existing schemas are modified to account for new experiences. Equilibration is the mastering stage that encompasses both accommodation and assimilation. Piaget argues for active learning that forms the basis of constructivism.

Jerome Brunner according to Driscoll (2005) proposed discovery learning theory. This is a method of inquiry based learning. Influenced by Vygotsky, Brunner emphasised that learning must be a process of discovery where learners built new knowledge from the existing. Learning is an active social process. Brunner argues that it is best for learners to discover facts by themselves. Discovery learning takes place in problem solving situations where learners draw from past experiences to discover facts and relationships and new truths to be learnt through object manipulation according to Brunner (2009). Discovery learning helps to develop creativity and problem solving skills on part of the learner. Opponents of the theory according to Driscoll (2005) argue that it creates cognitive overload which may result in potential misconceptions.

According to Driscoll (2005), constructivists believe that assessment should be used as a tool to enhance both the student's learning and the teacher's understanding of the student's progress instead of an accountability tool. Types of assessment aligned to this epistemological position include the use of portfolios, group based projects, debates and role play.

The assessment method becomes crucial in determining whether students have developed the necessary practical work skills to suit environments beyond the 'A' level physics laboratory. Cakir (2008) notes that constructivism is based on three cognitive theories by Piaget, Ausubel and Vygotsky. In order to learn students must carry out cognitive processes that construct relations among the elements of information in the concept. Cakir (2008) further notes that Vygotsky's zone of proximal development is a distance between the actual development level as determined through problem solving and level of potential development as determined through problem solving under adult guidance or collaboration with more capable peers. Ausubel and Piaget argue of existing schemata for a learner to meaningfully acquire new information or concepts according to Cakir (2008). Treagust and Duit (2008) argue that according to radical constructivism, knowledge is seen as tentative human construction on the basis of already existing knowledge. Some profound scholars (Treagust and Duit, 2008; Cakir, 2008; Trowbridge and Bybee, 2004) postulate that the basic tenets of constructivism are:

- Knowledge is actively built from within by a thinking person and not passively received through senses.
- Social interactions between, and among learners are central to the building of knowledge by individuals.
- Humans rely on shared or negotiated meaning.
- Children's alternative concepts are wrongly referred to as misconceptions.
- Emphasis on authentic tasks in meaningful context rather than abstract instruction out of context.
- Encourages thoughtful reflections on experiences.

This section briefly describes constructivism in science education. The constructivist approach accepts and encourages students' initiation of ideas. The argument here is that, students' prior knowledge, expectations and perceptions are important in the learning process. Treagust and Duit (2009:89) note that constructivist teaching approaches consider students' beliefs and conceptions towards student centred pedagogy in science instruction with the focus on students' interest, their learning skills and their needs in actively constructing their knowledge. According to Cakir (2008) science teachers should call attention to the process of science rather than just content. In other words, constructivist approaches must promote conceptual changes and development through use of activities. It is important therefore that in assessing practical work in science education, we need to consider the practical skills that students exhibit as they do practical work and assess them. When students are involved in the construction of their own learning through formative assessment, they develop the ability to monitor and regulate their learning. According to Trowbridge and Bybee (2004), what learners actually construct from a given learning experience varies from student to student as there is no conduit from one brain to another. Treagust and Duit (2008) argue that constructivist science education is humanistic in nature and it aims at supporting the development of individuals' personality. Students must be empowered to deal with challenges of their future lives. Cakir (2008) concurs by saying that students come into the classroom with an established worldview formed by years of prior experience and learning to such an extent that they are emotionally attached to their worldviews and would not easily give up.

The constructivists' views of science education are basically that; all knowledge is constructed as a result of cognitive process within human mind, prior knowledge impacts the learning process and that constructivism provides no specific answers but rather frames the questions and acceptable forms of answers. On assessment, constructivism calls for the elimination of grades and standardised testing as assessment becomes part of learning process so that students play a larger role in judging their own progress. However the role of assessment among other supporting conditions of conceptual change is given key importance. It must be noted in conclusion that, the pathway from students' pre-

instructional conceptions to science conceptions is evolutionary according to arguments of Treagust and Duit (2008).

### **2.3 Formative Assessment**

Assessment can be seen as the process of collecting, synthesising and interpreting information to aid decision making processes. It basically takes two main forms of formative and summative assessments. Literature however reveals that there are now some off shoots of terms referring to some kinds of both formative and summative assessments. Examples on formative assessment of practical work include direct assessment of practical work skills (DAPS) as defined by Reiss, Abrahams and Sharpe (2012:6) which McMillan (2004) refers to as authentic assessment. McMillan (2004:16) defines authentic assessment as assessment in which students are asked to perform real world tasks that demonstrate meaningful application of essential knowledge and skills. An authentic assessment usually includes a task for students to perform and a rubric by which their performance is assessed. Pedder (2006) refers to this as performance assessment in which students are assessed during tasks.

According to Shepard (2008:81), formative assessment is defined as “an assessment carried out during instructional process for the purpose of improving teaching or learning...making adjustments so as to inform new learning”. William and Leahy (2007) note that, an assessment is formative to the extent that information from assessment is fed back within the system and actually used to improve the performance of the system in some way. Black et al. (2003) see formative assessment as a process in which information about learning is evolved and then used to improve the teaching and learning activities.

Formative assessment takes different forms and ways. Bell and Cowie (2001) talk of Interactive Formative Assessment (IFA). Dufresne and Gerace (2004) write about Classroom Formative Assessment (CFA). Interactive Formative Assessment (IFA), according to Bell and Cowie (2001) takes place during teacher student interaction. The process involves the teachers noticing, recognising and responding to students’ thinking and it has more to do with teacher-student interaction than influenced by the curriculum. From the observations by Bell and Cowie (2001), it appears this kind of assessment generates information that is ephemeral as it involves the teacher’s reaction after noticing sections where the learner may need his help. This idea is supported by Fairbrother (2008:70) as he asserts that “only teachers can see students in action and assess their objectives, which are directly connected with their practical work and this is where they should be directing their time and effort”. Ideally, assessment should provide short term feedback so that obstacles can be identified and tackled very early within the process of learning. This is important as information from assessment affects subsequent teaching and learning activities.

Classroom Formative Assessment (CFA) is assessment during classroom activities. Dufresene and Gerace (2004) argue that CFA assists teachers to gain information about student understanding in order to enhance student learning. Classroom Formative Assessment (CFA) focuses on the interactions between teacher and small groups, on class wide discussion, on flexible teaching, on feedback to students and student self-assessment of their work and understanding according to Durfresene and Gerace (2004). Dufresene and Gerace (2004:428) identified the procedure to be followed as follows:

- Presentation of questions to class.
- Collection and storage of individual students' answers.
- Anonymous display of histogram of students' responses.
- Record of each student's progress.
- Reports of individuals or small groups.

The argument here is that students will have an opportunity to assess the success of their current models of interaction and becoming aware of areas needing improvement. It can be seen from the above procedure that CFA entails a shift in a classroom culture away from a teacher – centred, answer dominated focus, to a focus on students' mental process as they are manifest in analysis and reasoning activities.

Black and William (2004:140) assert that “formative assessment is not an instrument on an event but a collection of practices with a common feature that all lead to some action that improves learning”. It means therefore that this is an assessment that is specifically intended to provide feedback on performance to improve and accelerate learning. William and Leahy (2007:105) suggest that effective formative assessment consists of five key strategies:

- Clarifying learning intentions and sharing criteria for success.
- Engineering effective classroom discussion, questions and learning tasks that elicit evidence of learning.
- Providing feedback that moves learners forward.
- Activating students as the owners of their own learning.
- Activating students as instructional resources for one another.

### **2.3.1 Formative Assessment of Practical work**

“Success of formative assessment of practical work depends upon forward planning, flexible timetables and good will on the part of all involved” according to Fairbrother (2008:70). Fairbrother

(2008) identifies some options on effective assessment to include two teachers in one class, small group of experiments and to increase the number of technicians among many other strategies. The commonest feelings among teachers who are assessing practical work are those of insecurity and uncertainty. The solution according to Fairbrother (2008) is to plan well, to start assessing and recording as early as possible and concentrate on and assess a limited number of objectives. If practical work is assessed in a summative way this will not give maximum benefit to the students as practical work reports assessment divorce the theoretical aspects of practical science from hands on practice despite both being integral skills. Practical reports assessment according to arguments by Downs (2013:1) misrepresents the nature of science and poses risk in reducing the amount of practical work skills manifested by students. If students' practical work skills are assessed in a summative way, there is danger in leaving students poorly equipped in skills required by higher education and other progression routes in sciences.

### **2.3.2 Advantages of Formative Assessment**

Let me summarise this theoretical framework by looking at the advantages of formative assessment. According to Black and William (2004:143), "formative assessment encourages reflective practice and evokes students' understanding". It does not focus on comparison but advice on what a student can do to improve. It addresses the questions:

- Where are you trying to go? (Provides students with a clear vision of learning targets).
- Where are you now? (Self-reflection).
- How can you get there? (Helps students with strategies and skills to reach the goal) according to Shepard (2008).

Dufresne and Gerace (2004) note that the rationale for formative assessment is to effectively monitor and influence the development of students' thinking process, inquiry skills, attitudes towards science and learning behaviours. To achieve this it requires continuous forms of assessment integrated into everyday learning activities. Regular use of classroom assessment would raise student achievement in maths and science as evidence about student learning is used to adjust instruction to better meet student needs as learning is adaptive to students' learning needs from observations by William and Thompson (2007). Literature has shown that the power of formative assessment in monitoring student learning and acquisition of practical work skills cannot be over emphasised.

## **2.4. Assessment in Constructivism**

According to Taber (2002), the constructivist approach has been a dominant influence on the direction of much research into learning science. The constructivist view on learning emphasizes how meaningful learning occurs when the learner associates the new information with something seen as relevant within their existing knowledge. Constructivist teaching is based on the constructivist learning theory. According to Hodson (2006), this theoretical framework holds that learning always builds upon knowledge that a student already knows. Constructivists believe that learning is more effective when a student is actively engaged in the learning process rather than attempting to receive knowledge passively. In science, there is a widespread concern that the learners often fail to appreciate the nature of science as activity based discipline according to Taber (2002). Current approaches to assessing science may well be contributing to this problem.

The major problem is to have valid and credible assessment. Assessment is a tool for learning. Good assessment requires a variety of measures so as to match with the envisaged outcomes. According to Segers, Dochy and Cascallar (2003), assessment methods used should be valid, reliable and consistent bearing in mind that there is need to focus on outcomes and processes. Traditionally, assessment in the classroom is based on testing. According to Taber (2002:3), exam boards are more concerned with summative assessment which is designed to provide a measure of achievement at the end of the course of learning largely limited to the end of schooling and as such, much teaching is directed at the examination. On the other hand, in the constructivist teaching, the process of gaining knowledge is viewed as being just as important as the product. Formative assessment is the widely accepted form of assessment in the constructivist learning. The learners are evaluated in the process of creating their competencies and abilities. In the constructivist theory, assessment is viewed as part of the learning process in which students play a greater role in judging their own process. The major role of formative assessment is to guide the learners to understand their learning states and see improvement with clear goals, according Hudson (2009). Both content knowledge and various skills need to be measured in multiple ways for teachers to gain a better picture of students' achievement as further argued by Hudson (2009).

According to Taber (2002), meaningful learning occurs when the learner is able to anchor new information to that bedrock of existing knowledge. Taber (2002) further notes that as the body of existing knowledge may include various alternative conceptions, and as new information may be judged to be relevant to prior learning in unintended ways, such learning need to be appropriate just because it is meaningful. Diagnostic assessment becomes important for constructivist learning to get students' prior knowledge in order to clear their misconceptions.

Current assessment practices need to reflect on changes based on new knowledge and skills that are relevant for the 21<sup>st</sup> century according to Segers, Dochy and Cascallar(2003). Segers et al (2003)

further assert that, assisting students to develop knowledge skills and behaviours and become lifelong learners requires changes in assessment processes at the school and classroom levels. Assessment in constructivism gives much more detailed insight into the actual skills of students. Learning requires educators to consider whether the available methods of assessment are appropriate or satisfactory according to Mintzes, Wandersee and Novak (2005). Assessment process should emphasize students' ability to link ideas, apply knowledge and solve problems according to Segers et al (2003). Constructivist assessments allow students to develop higher order thinking and become independent autonomous learners. According to Shepard (2000), teachers need to find support and a way of protecting their own understandings of constructivist assessment and practices from the onslaught of test driven curricula. Constructivist assessment entails the use of assessment in the process of learning. Practical work is one of the tools which can be used in this process.

Practical work provides insight into, and experience and practice of methods of science according to Hodson (2006). Hodson (2006) further notes that practical work needs to project an image of science that more faithfully reflects actual scientific practice. Practical work assessment should not be based only on practical tests but also on observation of students engaging in practical work activities. According to Hodson (2006), during practical work, the constructivists encourage teachers to use checklist and observation to assess student success with a particular practical activity.

While constructivist learning theory has many advantages, it is also important to consider some of its weaknesses before concluding this section. According to Kirschner, Sweller and Clark (2006:78) constructivist description of learning is accurate but the instructional consequences suggested by constructivists does not necessarily follow. Constructivist theories are more descriptive than prescriptive. Mayer (2004) notes that constructivist theory is biased to students who desire to learn more and are capable of focussing attention to the learning process independently. A mixed approach that incorporates components of constructivist learning along with approaches including more guided strategies would better meet learners' needs accounting for differences between learning styles and capacities according to Kirschner et al (2006). Despite the importance of formative assessment in constructivism, summative assessment remains an important aspect of practical work assessment in science education.

## **2.5 Assessment of Advanced Level physics practical work skills**

Zimbabwe largely adopted the Cambridge syllabus when she took over the administration of ordinary and advanced level examinations under the management of Zimsec. The 'A' level Zimsec physics syllabus was basically adopted from the 'A' level Cambridge International examination one. As

outlined in the context of the study section, as part of the expectations of the Zimsec physics syllabus students are expected to do weekly practical sessions from mainly past examination question papers and a few from Zimsec recommended textbooks. During the practical session students are often assisted by laboratory technicians. At the end of each practical session, students are expected to submit a practical work report which is then marked by a physics teacher where mainly presentation skills are assessed. These weekly practical tests are done in preparation of the final two and half hours practical examination which is written at the end of the two year course which is again assessed on the basis of the submitted practical work report according to the requirements of the Zimsec ‘A’ level physics syllabus (9188). It is interesting to note at this juncture that according to the ‘A’ level physics syllabus (9188), some of the experimental skills to be gained by the students during the course are:

- The ability to identify a problem, designing and planning an investigation.
- Making observations and measurements with due regard to precision and accuracy.
- Ability to handle instruments and apparatus including techniques of operation and safety.

It might be difficult to achieve these goals considering that the assessment of practical work is done through a practical work report where these skills are inferred. A relationship between practical skills developed and the valued goals of science education as outlined in the physics syllabus (9188) must be witnessed. Reiss, Abrahams and Sharpe (2012:6) define practical skills as those skills the mastery of which increases a student’s competence to undertake any type of science learning activity in which they are involved in manipulating and/or observing real objects and materials. There must be a link between how practical work is done and how it is assessed. The ‘A’ level physics practical course must facilitate the development of essential scientific and technological skills as foundation for future growth. There is need to have practical work activities that are compatible with society’s expectations and aspirations. The ability to manipulate equipment and coming up with results will form the basis and prepare students for their societal roles thus reviewing the methods of physics practical work assessment becomes crucial. The physics laboratory environment needs to be fully utilised in the development of manipulation, investigation and design skills in addition to presentation skills. Reiss, Abrahams and Sharpe (2012:6) argue that practical skills are best assessed directly as they further assert as an example that, whilst conceptual understanding of the topology of knots and manifolds might well be assessed by a written task, the most effective means of assessing whether a student is competent in tying their shoe laces would be to watch them as they attempt to tie them. The major problematic question remains that: How can experimental skills as outlined in the syllabus (9188) be fully assessed on the basis of the submitted practical work report?

It is important to look at how practical work is currently assessed in England since the current Zimsec syllabus was adapted from the University of Cambridge International Examinations one. Before doing that however it is necessary to look at some theoretical perspectives regarding the assessment of practical work. Reiss, Abrahams and Sharpe (2012:6) identify two distinct ways in which practical work can be assessed which are the direct assessment of practical work skills (DAPS) where students are assessed as they manipulate real objects to determine their level of competence in that skill and indirect assessment of practical skills (IAPS) where student's level of competency is inferred from their data and/or reports of practical work that they undertook. Table 2.1 gives a summary of the conceptions of Reiss, Abrahams and Sharpe (2012:6) on DAPS and IAPS.

Table 2.1: A comparison of DAPS and IAPS

	<b>DAPS</b>	<b>IAPS</b>
<b>What is the principle of assessment?</b>	A student's competency at the manipulation of real objects is directly determined as they manifest a particular skill.	A student's competency at the manipulation of real objects is inferred from their data and/or reports of practical work they undertook.
<b>How is the assessment undertaken?</b>	Observations of students as they undertake a piece of practical work.	Marking of student reports written immediately after they undertook a piece of practical work.
<b>Advantages</b>	The validity is very high. It encourages teachers to ensure that students gain expertise at the practical skills that will be assessed.	More straightforward for those who are undertaking the assessment.
<b>Disadvantages</b>	More costly. Requires teachers or others to be trained to undertake the assessment. Has a greater moderation requirement.	The validity is low. Less likely to raise students' level of practical skills.

(Adapted from Reiss, Abrahams and Sharpe, 2012:6)

Reiss, Abrahams and Sharpe (2012:6) observe that the main awarding bodies in England currently uses IAPS model when assessing learner practical work. It means the focus is more on what students know about practical work than on their competency in terms of actually how they do the practical work themselves. According to Reiss, Abrahams and Sharpe (2012:10) practical work at Advanced Level physics contribute about 15% of the total marks. Physics teachers according to the Cambridge

syllabus are expected to use both the DAPS and IAPS during the period students will be undergoing the Advanced Level physics course though the marks awarded during the preparatory practical sessions do not contribute towards the final examination which is solely marked using the IAPS basing on the submitted practical work report. The range of skills assessed using IAPS for Advanced Level physics practical according to the University Of Cambridge International Examinations syllabus of 2014 include questions on:

- Describing in simple terms steps in carrying out practical procedures.
- Identifying/selecting apparatus to be used to carry out practical procedures.
- Identifying, designing and carrying out practical work activities.
- Using a range of skills, including where appropriate new technologies and problem solving to take decisions to achieve planned outcomes.
- Following instructions for drawing diagrams.
- Taking readings from graph by interpolation and extrapolation.
- Determining gradient, intercept or intersection on graph.
- Drawing conclusions.
- Explaining and suggesting possible improvements to techniques and procedures.

Oxford, Cambridge and RSA (OCR) examination board in its IAPS emphasizes on:

- A report on quality measurement or study of physical relationships.
- A report on practical investigations related to physics and its application.
- Research briefing where a short written and verbal report based on individual work of a candidate summarising a topic of physics of his or her own choice is assessed (OCR, 2010:52).

Practical work assessment in England done by different examination boards at ‘A’ level Physics have shown that students are mainly not directly assessed in terms of specific practical work skills save for Assessment and Qualifications Alliance(AQA) examination board where ,following the route T model, only six marks out of the possible 50 marks are assessed using DAPS. Edexcel and OCR examination boards among major awarding boards assess practical work at Advanced Level using IAPS model according to SCORE (2009:3). This assessment is focused primarily on assessing students’ understanding of practical work rather than their competency in actually doing it according to Reiss, Abrahams and Sharpe (2012:9). It is promising to note that under the AQA route X model, whilst the externally marked practical assignment is assessed solely using IAPS, there is a

requirement for what is termed ‘Practical Skills Verification (PSV)’ according to AQA physics, 2013. During the PSV, teachers are required to verify their candidates’ ability to demonstrate safe and skilful practical techniques and make valid and reliable observations. Though PSV does not contribute towards the assessment mark the student is only allowed to go to the next unit if the teacher verifies that the student has completed the practical tasks.

It must be noted in conclusion that both Zimsec and major examination boards in England assess ‘A’ level physics practical work using the IAPS where students are expected to write a practical work examination at the end of the course and the assessment then based on a submitted report. The emphasis using the IAPS is more on the assessment presentation skills than other important skills like observation, manipulation and designing.

## **2.6 Some perspectives on the assessment of practical work**

Practical work is important for developing students’ scientific knowledge that facilitates acquisition of key skills. There must be a link between how practical work is done and how it is assessed. There is need to develop effective and efficient strategies and procedures for the assessment of practical work, (Bell and Cowie, 2001). To achieve this, emphasis must be towards skill based assessment. Treagust (2008) criticizes practical assessment as means of assigning students to their grades in a summative manner. Hoult (2002) observes the need by teachers to properly assess practical work so that students can develop skills such as observation, manipulation and designing.

In any fair analysis, it is imperative to weigh the advantages and disadvantages of summative against formative assessment of practical work. Problems of validity are also associated with summative assessment where according to Mathews and McKenna (2005) issues of rewarding student for work done and assessing the quality of their work are difficult to distinguish. These cautious observations from earlier researchers serve to highlight that there is no simple way to assess students’ practical abilities reliably and validly.

In this section it is important to look at how practical work in science is generally assessed outside Zimbabwe and England with particular reference to the assessment of practical work in ‘A’ level physics. Mathews and Mckenna (2005) carried out an evaluation of the model of practical work assessment in Ireland adopted from Bennet and Kennedy (2001) and a council report of 1997 in which practical work is assessed by external examiners in a three phase continuum. Phase 1 involves the assessment of practical notebook with a series of practical work done. Phase 2 involves the ability to explain the practical work which they have performed and phase 3 involved assessing the generic practical skills including equipment manipulation and making measurements as outlined in the syllabus. They observed that in phase 1 for example, there was no link between write up and the ability of a student to perform a practical, compromising the validity of the skills assessed. They noted

the confusion that arises over rewarding students for work done and assessing the quality of their work. In phase 2 the assessment procedure was considered not reliable due to variation in the nature of practical work activities. The marking scheme imposed three discrete points on what could be a continuous scale. Students were generally good in presentation.

Mathews and McKenna (2005) concluded that the matter of assessing practical work remains a key issue in Irish science education as elsewhere. There has been little attempt to identify in detail the knowledge and skills associated with practical work that are desirable and capable of being assessed rigorously and that physics teachers are not involved in the assessment of practical work.

Wellington (2004) notes that Techniques for Assessment of Practical Skills in Science (TAPS) started in Scotland. Six skills of observation, recording, measurement, manipulative, procedural and following instructions were identified for assessment. Though this system had associated advantages, Erickson and Meyer (2003) warns that discrete assessment of practical work activities might result in the loss of some important aspects where different skills interact with each other.

Nadji, Lachi, and Blanton (2003:57) advocate for an approach which combines formative and summative approaches to practical work assessment with the advantage of reducing the amount of the quantity of written work to be assessed. Students must learn the act of doing science by using an experiment to develop science rather than just validating it (*ibid*). This can only be achieved using an embedded assessment system. Nadji et al. (2003) argue that physics practical work in the United States of America must be assessed using the embedded assessment system following the work of the Berkley Evaluation and Assessment Research Centre (BEAR). According to this a system, a holistic approach of assessment from lab based activities to practical write up was employed. Four levels of performance for each component were identified that is: incomplete, incorrect, complete and correct. Students were scored accordingly. This sounds to be a better way of assessing practical work than administering practical tests.

Observations by Abrahams, Reiss and Sharpe (2013:240) are that, China, Singapore, New Zealand and Finland often described as high performing countries all make use of a substantial proportion of direct assessment of their students' practical science skills at some point in their schooling system. The argument for this policy is that students' practical skills competencies can only be determined from direct assessment of practical work skills otherwise IAPS only helps to determine the process skills.

In China for example, practical work in science is assessed using the DAPS model where the requirements of practical examination state that it must be checking students' skills and procedures of conducting practical work, their abilities of selecting and using instruments and other safety precautions according to Reiss, Abrahams and Sharpe (2012:23). The actual assessment of students'

performance in conducting practical work is partly based on the report submitted by the teacher after directly observing and assess between two to four students in twenty minute examination. Students are also expected to submit a practical work report to complete the assessment process. This according to Reiss, Abrahams and Sharpe (2012:23) is done in the assessment of practical work in subjects like biology, physics and chemistry. The case is slightly different in Finland where according to Lavonen and Laaksonen (2009:930) the final mark for practical work assessment in science is a product of formative assessment during the course and summative assessment at the end of it. The DAPS model is used by teachers when assessing students in both the formative and summative manner.

In Singapore, the assessment of practical work in science with particular reference to the assessment of practical work in physics has shifted from a summative to a more formative approach. There is comprehensive assessment of experimental and investigative skills covering areas of observing, manipulation, analysis and planning of practical activities including appropriate procedure for an investigation. According to Reiss, Abrahams and Sharpe (2012:24) students are assessed on these skills by teachers in two combined skills tasks(of one hour fifteen minutes duration) within a specified window period once in each academic year of the two year ‘A’ level course. Reiss, Abrahams and Sharpe (2012:25) observe that a survey of students’ views showed that they felt the approach assessed their practical skills more accurately because of its formative nature and gave them more opportunities to demonstrate their abilities as compared to one- off practical examination. Let me at this juncture give a detailed account on Singapore’s shift from IAPS to DAPS over a period of five years. The reason for detailed analysis of this shift is based on the fact that both Singapore and Zimbabwe’s examinations were both once run in collaboration with the Cambridge International Examination Board.

According to Hoe and Tiam (2010:1), Singapore embarked on a radical shift to School Based Assessment (SBA) breaking a long tradition of a once off summative practical examination of the Singapore-Cambridge General Certificate for the Advanced Level (GCE-A level). The rationale for that radical shift was that school based assessment offered the potential for formative and comprehensive assessment of experiment and investigative skills. This according to Hoe and Tiam (2010:1) was necessitated by the weaknesses of indirect assessment of practical work which included the tendency to concentrate on written product without due emphasis given to process of investigation. The other major problem noted of IAPS was the realisation of limited use of sophisticated equipment in the practical examination due to logistical problems or limited availability. The government of Singapore argued that learning activities needed to go beyond merely obtaining grades but should broaden to equip students with the skills and competencies for the new millennium

through creative problem solving and critical thinking in curriculum design and assessment. Schools introduced self-directed project work as per advice of the Ministry of Education (MOE) as from 1999. The skills that were to be developed and subsequently assessed from the observations by Hoe and Tiam (2010:2) included problem identification, literature review, designing and investigation, implementing and testing the experiment and making innovations along the way to pursue meaningful conclusion. In-service teacher training was first introduced early 2000 to prepare teachers for implementing SBA. The idea according to Hoe and Tiam (2010:2) was to improve the teachers' evaluative and inquiry skills. The project was pilot studied and in 2004 SBA eventually replaced the practical examination.

Practical skills were divided into four categories of planning, manipulation, analysis and evaluation. Each skill had to be assessed twice on different topics in the two year 'A'- level course. According to Hoe and Tiam (2010:2) centres could select from a pool of assessment tasks provided by the examination board where moderation was done at both school and national level. The Singapore Examination Board later realised that the assessment of planning school could be done through a written examination as the objective could be achieved without any logistical problems. This shift however did not come without its own challenges. It was difficult to manage the role of a teacher-cum-assessor as cheating could not completely be ruled out. There was need to minimise the teacher-assessor dual role conflict though it was impossible because of limited manpower. It also increased the workload of the teachers mainly due to lengthy discussions at internal moderation level. According to Hoe and Tiam (2010:2) a number of measures were taken to address the problems. These included:

- Continuous in-service training to improve on internal assessment.
- Reduction of assessment criteria for the four skills from eighteen to fifteen.
- Centres were provided with more laboratory technicians to assist during assessment.
- Centres were given the autonomy to make minor modifications to existing assessment tasks though centres needed justification for those modifications.
- Discrete assessment of skills was replaced by a holistic approach by 2008 to avoid "compartmentalised teaching and learning of practical skills", Hoe and Tiam (2010:3).
- Centres were given the autonomy to extend the assessment duration by up to twenty five percent.

- By 2010 the assessment of the three skills was incorporated into two combined skill tasks to be assessed within a specified window period once in each academic year of the two year ‘A’ level course where tasks were released by the exam authorities just before the window period.

Quite a number of benefits were realised as result of this shift in the assessment of science practical work. The benefits according to Hoe and Tiam (2010:3) include:

- An increased teachers’ competency in the teaching and learning of practical skills in scientific inquiry.
- An improvement of teachers’ practical marking skills.
- Professional development of teachers through internal moderation.
- Continuous assessment of pupils to improve opportunities as compared to a one off practical examination.

The Singapore story shows a great achievement in trying to improve the validity and reliability of practical work assessment. Pupils are assessed on their competencies rather than on a process of doing practical work. It is important for Zimsec to pluck a leaf from the Singapore experience if ‘A’ level physics students are to get necessary practical work skills that are important in environments beyond the ‘A’ level physics laboratory. Though the current method of practical work assessment appears to be objective, alternative models need to be considered almost two decades after the localisation of ordinary and advanced level examinations. Re-branding of the education system in general and physics education in particular become important as innovation is necessitated by the desire to achieve the best. To this end, this achievement cannot only be entrusted to the board that is responsible for national examinations but it must be the responsibility of all stakeholders including industrialists, academics and the progressive society at large as a means of value addition in science education. A nation should not have the same education system as far as the assessment of ‘A’ level physics practical work is concerned more than three decades after gaining independence.

The case of assessment of practical work is a bit different in Australia where the systems vary from one state to the other. According to Reiss, Abrahams and Sharpe (2012:25) in Queensland and Australian Capital Territory, school based assessment is used where as in other five states external examinations are used. On average practical work contributes about 15% of the final mark. According to Educational Assessment Australia (2013) policy document, the range of skills that are assessed for practical work in science using DAPS include measuring, observation, interpreting diagrams and graphs, investigation and problem solving. Online interactive multimedia assessment tests are also used to assess science practical work skills under the IAPS model. In Australia, the IAPS and DAPS are used when practical work is being assessed.

It must be noted in conclusion that unlike the IAPS model which is predominantly used by Zimsec and major examination boards in England ,China, Singapore, Finland and Australia make use of the DAPS. Though in both models the importance of acquisition of practical work skills by students is emphasised, the term practical skills is interpreted differently considering the DAPS and IAPS models. From the above observations it can be noted that, the assessment methods are still undergoing metamorphosis. The current study will thus like to look at the effects of Zimsec physics practical tests on skills development where a model on the ongoing ‘perfections’ is proposed for the Zimbabwean case.

## **2.7 Assessment of practical work in other subjects and qualifications: Towards an alternative model**

It is important to look at how practical work is assessed in other subjects to draw lessons for the improvement on the assessment of practical work in ‘A’ level physics or alternatively for the development of a proposed new model of practical work assessment. An insight into the way in which other subjects assess practical work may be an eye opener to the physics curriculum developers. A synopsis of the assessment of practical work and projects by Zimsec syllabi of woodwork (6035), metalwork (6045), geometrical and mechanical/building drawing (9196), building studies (7035), fashion and fabrics (6051) and food and nutrition (6064) is going to be given. Assessment of practical work in other qualifications in England will also be considered in this section. This will then be compared to the way in which practical work is assessed in Advanced level physics and conclusions drawn.

Assessment of practical work in the technical subjects offered by Zimsec basically entails the production of an artefact during the two year ordinary or ‘A’ level course where the internal teacher will score the candidate on the basis of the quality of the product produced. The marks obtained are then moderated by assessors appointed by Zimsec using the marking scheme provided by the examining board. According to the ‘A’ level Geometrical and Mechanical/building drawing syllabus (9196) offered by Zimsec the major assessment objectives/skills include:

- The ability to produce fully dimensioned and annotated working drawings of mechanical/building component(s) from dimensional sketches.
- The ability to produce orthographic or pictorial views of mechanical/building components working from pictorial and orthographic drawings.

Candidates are also expected to sit for practical examination which is assessed using the IAPS and contributing 40% of the final mark. In addition to the practical examination the candidates are also expected to do a project. The project results in production of an artefact where the internal teacher

will score the candidate on the basis of the quality of the product produced. The marks obtained are then moderated by assessors appointed by Zimsec using the marking scheme provided by the examining board. The project which is assessed using the DAPS model contributes about 20% of the final mark. It can be noted there that practical work assessment using both the DAPS and IAPS contribute about 60 % of the final mark where theory only contribute 40%. This is a great deviation considering that in science, practical work assessment only contributes about 20% and solely assessed using the IAPS model.

The situation is almost similar considering the Fashion and Fabrics Zimsec syllabus code numbered 6081 of 2014 where the major assessment objectives or skills include:

- Ability to demonstrate the correct handling, use and care of different fabrics.
- The ability to design and draft patterns.
- The construction of well finished garments, accessories and craft.

To this end, candidates are expected to sit for a practical examination marked on the basis of the produced artefact using the DAPS model. The practical examination contributes about 40% of the final mark. In addition to this candidates are also expected to do a project resulting in the production of an artefact and is marked using the DAPS model. The internal teacher will score the candidate on the basis of the quality of the product produced. The marks obtained are then moderated by assessors appointed by Zimsec using the marking scheme provided by the examining board. The project contributes about 20% of the final mark. Unlike the ‘A’ level Geometrical and Mechanical/building drawing syllabus(9196) where practical work is assessed using both the IAPS and DAPS, practical work assessment according to the Zimsec Fashion and Fabrics (6081) syllabus of 2014 employs the DAPS model only.

According to the Zimsec Food and Nutrition (6064) syllabus of 2014 the major skill which is assessed when students are doing practical work is the ability to demonstrate various methods of cooking food using different pieces of equipment. Practical work is assessed using the DAPS model with a weighting of 50% of the final mark. The situation is almost similar considering the Zimsec metal work syllabus (6045) of 2014. According to this syllabus, the major assessment objectives or skills include the ability to:

- Demonstrate knowledge of safety regulations on work in a metal workshop.
- Perform basic sheet metal and forge work operations.

Candidates are expected to sit for a practical examination which is assessed using the IAPS and contributing about 40% of the final mark. In addition candidates are also expected to do the design

project resulting in the production of an artefact. The internal teacher will score the candidate on the basis of the quality of the product produced. The marks obtained are then moderated by assessors appointed by Zimsec using the marking scheme provided by the examining board. The project which is assessed using the DAPS model contribute 20% of the final mark. The mode of assessment is similar considering the Zimsec Wood Work syllabus (6035) of 2014.

Assessment of practical work in other qualifications and subjects in England is almost similar to the way it is done in Zimbabwe. According to OCR (2013), fieldwork in Geography is assessed using the IAPS where candidates are expected to submit a fieldwork report for marking. Fieldwork contributes 25% of the total marks. According to Reiss, Abrahams and Sharpe (2012:14), the OCR design and technology syllabus requires candidates to carry out internally assessed practical work that constitutes about 60% of the total marks. The skills that are assessed include development of designing skills, making skills and critical evaluation skills. The DAPS model is used for the assessment of these skills using the examining board's marking scheme and the marks are moderated by OCR. Candidates are also expected to produce an artefact. The assessment of practical work in Music at GCSE and associated board of the royal schools of music is done using the DAPS model and contributes about 25% of the available marks with theory tests catering for the remaining 75%. The DAPS model is also used for the assessment of practical skills for Modern Foreign Languages according to Reiss, Abrahams and Sharpe (2012:14) with a weighting of 30%.

It is the assessment method that influences how practical work in science is taught and done as observed by Abrahams and Millar (2008), Abrahams and Saglam (2010) and Abrahams and Reiss (2012). More needs to be done on the assessment of physics practical work to ensure that students have the necessary science practical skills needed for destinations beyond the advanced level science laboratory from the arguments by Grants (2011), Grants and Jenkins (2011) and Gatsby (2012). Reiss, Abrahams and Sharpe (2012:32) note however that while it is clearly impossible to teach the full range of practical skills that every employer and higher education institution desires enabling school students to gain experience of a reasonable number of major practical skills will benefit them far more than having no such experience at all. Science educators need to pluck a leaf from the way practical work is assessed in other subjects to witness an improvement in skill development of advanced level physics students.

## **2.8 Lessons drawn from literature on the assessment of practical work**

From several arguments presented and discussed in section 2.1 to 2.4 above, some major lessons emerged as relevant in addressing the research questions of the study. This section gives a synopsis of the lessons drawn from literature on the assessment of practical work with regards to IAPS and DAPS. It also looks at the models of practical work assessment ranging from the use continuous

assessment (course work), open ended project methods, production of artefacts and portfolios of practical skills, weighing the advantages and disadvantages of each model and mapping the way forward on the basis of what is already in literature. Challenges faced by different countries in trying to bring about innovation in the way practical work is assessed as well as envisaged benefits thereof are also highlighted in light of the research problem of the current study.

Assessment of practical work remains the weakest aspect of teaching and learning of science. Race (2005) discusses the importance of putting assessment into context and stress the need for teachers to consider many aspects of assessment. The aspects include knowing why to assess, what to assess and what quality of feedback they should provide to their students. In this regard, the observation method needs to be considered as an option to collect assessment data about students.

A number of assessment methods can be used to assess ‘A’ level physics practical work and the constructivist theory of learning appears to support some of them. Constructivism as a theory of learning becomes important in guiding students to learn in a laboratory, starting with the aim of achieving a goal of learning by doing. Both IAPS and DAPS are important in the assessment of practical work skills of ‘A’ level physics students. The strategies must not be used as competitive models but complimentary assessment methods.

The role of both teachers and students are important for the success of any assessment strategy. It is important for teachers to know the skills which they must assess on students in order to produce a dynamic product prepared to face challenges beyond the ‘A’ level physics laboratory. An improvement in assessment practices can only be realised if it includes those assessment methods that emphasises formative approaches. The challenge of this study is therefore to improve assessment strategies of teachers and ultimately assist in the implementation of the proposed model to be developed by this study. The proposed model can only be developed when one fully understands how practical work skills of ‘A’ level physics students are assessed in schools so that an effective intervention model can be developed as an alternative to the current way of doing it.

Attention to improve assessment practice can enhance learners’ achievement according to Grants (2011), Grants and Jenkins (2011), Gatsby (2012) and Reiss, Abrahams and Sharpe (2012). Literature also reveals that the current type of assessment through practical examination appears to encourage rote and superficial learning as assessment powerfully frames how students learn as well as their achievement considering some works of Mathews and McKenna (2005), Lavonen and Laaksonen (2009) and Reiss, Abrahams and Sharpe (2012). Stacey and Spielman (2014) suggest that students’ practical work should be assessed by non-exam assessment and accounting for 15% of the total marks. This is done through school based practical work skill assessment. There is need to encourage breadth and variety in practical work skills assessment.

Countries like China, Singapore, Newzealand, Australia and Finland among others make use of direct assessment of their students' practical science skills at some point in their schooling system. Abrahams et al. (2013:218) observe the need to take note of some issues surrounding direct assessment of practical work skills. To adopt this system, there are a number of considerations in particular the manageability for schools, the best monitoring and checking arrangements.

Manageability issues according to Abrahams et al. (2013:224) include monitoring teacher student ratio. Teachers need to observe directly and carefully a sufficient amount of each student's practical work on a wide range of specified skills to the required standard. This is however not manageable by a single teacher yet with too few tasks the assessment will not be valid. Issues of subjectivity and cheating need also to be considered as teachers will have pressure for producing good results at the expense of developing students' practical work skills. This is so because promotion opportunities often are related to students' performance. According to Abrahams et al. (2013:228), "teachers may be tempted to inflate the grades of their own students as stakes are too high to expect them to do this honestly". This problem can be solved by bringing in visiting examiners to have independence of judgement. Viability and cost issues need to be considered as those external examiners will also be serving science teachers unlikely to be freed from their schools. These observations only serve to highlight the complexity associated with valid and reliable assessment of 'A' level physics practical work. The assessment of science practical work therefore remains a thorn in the flesh of science education in general and physics education in particular.

One way of solving this problem according to Abrahams et al (2013:230) may be through cluster moderation. It involves teachers observing and marking across a cluster of schools and comparing them with each other and with national standards and adjusting marks accordingly. Though this is better as compared to using internal teachers, concerns over logistical and other modalities in terms of time and cost may arise. Stacey and Spielman (2014:9) observe that in Queensland, Australia, cluster moderation is used on written work rather than visiting centres where practical skills are demonstrated. This is more or less like a practical examination the disadvantages of which have been explained clearly earlier. The other problem noted by Abrahams et al. (2013:230) is that it is possible to determine whether a student has a given skill, but much harder to determine grades or levels of performances. The assessment need to be valid reliable and provide effective discrimination between levels of performance.

Stacey and Spielman (2014:17) note that it is difficult for teachers to simultaneously assess each student. The other problem noted is that requirement for assessment time could have a noticeable impact on teaching time. By trying to solve one problem in the assessment of practical work one is bound to be creating another problem and this vicious cycle needs to be approached with caution. The

only solution as directed by literature is to use both DAPS and IAPS leaving one with the problem of the percentage weighting of each technique in the final assessment of practical work.

According to Abrahams, Reiss and Sharpe (2013:228), “If the intention is to determine competence, then direct assessment is the best, whereas if the intention is to determine skill process, then indirect assessment would be the preferred option”. Lunnetta, Hofstein and Clough (2007:399) note that using IAPS teachers are less inclined to devote time and effort to develop students’ practical skills. DAPS has the disadvantage that it tends to result in the use of laboratory activities that can be undertaken easily in a restricted time according to Lunnetta, Hofstein and Clough (2007:399). Using DAPS, Stacey and Spielman (2014:15) observe that “some things of value are impossible to assess validly”. The main advantage of DAPS is that, it would enable students to be tested on specific and relevant practical work skills. According to Stacey and Spielman (2014:18), practical examination would only be able to sample a relatively small proportion of the subject content. Practical examinations have however an advantage of manageability in schools and to students and also the possibility of producing valid and reliable results.

Another proposal on the assessment of practical work skills as revealed by literature is the use of open ended project work. Candidates are able to explore a practical project of their own making. Stacey and Spielman (2014:19) argue that this has a great potential for developing a wide range of practical and inquiry skills of students. This is however an indirect way of assessing the practical work skills of students with a strong emphasis on the assessment of investigative skills. To this end Stacey and Spielman (2014:20) argue that “there are significant design challenges in developing, delivering and awarding assessment models that are likely to produce nationwide results that are reliable and sufficiently comparable”. The challenges faced in using open ended project work may be reduced by asking students to submit an individual report in addition to the artefact that will be used as a basis of assessment.

The use of portfolios of practical work skills through coursework in addition to practical examination is another method of assessing practical work which is documented in literature. According to Abrahams et al. (2013:230), this is done through controlled assessment where students do tasks set by examination boards over the duration of their course. The assessment is however done by internal teachers. This method according to Stacey and Spielman (2014:21) may face challenges in that:

- Schools tend to concentrate on those tasks at the expense of other practical work skills in the process narrowing the curriculum.
- Students typically receive higher marks for controlled assessments marked by their teachers than for written exams.

- It can create unfairness among schools because of different interpretations of the amount of assistance teachers may provide to students.

Other methods of assessing practical work as revealed by literature include the use of practical work inventory where schools offer their students wide and varied experiences of practical work activities. This record according to Stacey and Spielman (2014:21) is kept at the school and availed to exam boards prior to examination. The records can be in form of laboratory notebooks, scripts, portfolios artefacts or virtual forms. By using this method practical work will be an integral part of the course of study rather than a one off, high stake assessment. The practical work activities done will be based on:

- Aims of the syllabus.
- Practical work activities specified by exam boards.
- List of apparatus and techniques.

As an example equal as an examination board recommends the following practical techniques in physics:

- Ability to measure mass, displacement and volume to determine densities of solids and liquid objects.
- Use of thermometers and electrical measuring instruments with heating and cooling devices to explore energy transfers.
- Use of instruments to measure distances and times to determine speed and acceleration.
- Measuring speed of both sound and of waves on water.
- Use of low voltage power supplies, ammeters and voltmeters to explore the characteristics of a variety of circuit elements.
- Connection or checking of the three wires for an AC mains plug and checking of the way these wires are connected to a domestic device.
- Safe and careful handling of electrical power supplies, experiments involving accelerated and uniform movement of objects and effects of steady or oscillating light sources.
- Use of springs and strings with weights to explore linear, elastic and inelastic stretching.
- Use of iron fillings and magnetic compass to explore fields of magnets, electric wires and solenoids. Stacey and Spielman (2014:27).

These practical techniques are derived from the aims and objectives of the ‘A’ level physics syllabus. The techniques are examined over a period of the two year course as it is almost impossible to examine all these skills at the end of course written practical examination.

As a way of summarising this section, the following should be considered when considering a model of practical work assessment in physics:

- Is the method of assessment encouraging a wide range of physics practical work skills to be assessed considering the curriculum aims?
- Is the assessment valid and reliable? Does it test the right things and is this done accurately and consistently?
- The ability to withstand accountability pressures by avoiding unmanageable contradictions on teachers by acting as an assessor and judging themselves through the outcome of the assessment they make. Stacey and Spielman (2014:40).

In conclusion, each approach has its benefits and drawbacks with no one perfect solution. Literature has revealed that there is no best way of assessing students’ practical work skills and there is neither sufficient research on important skills to be assessed hence the need to search for new ways of doing it. Amongst all mentioned assessment strategies, DAPS appears to be of significant importance in assessing students’ observation, measurement, manipulative, recording and design skills. Despite the importance of DAPS in determining whether a student has a given skill or not, the challenge remains of determining the grade or level of competence in that skill.

## **CHAPTER THREE**

### **RESEARCH METHODOLOGY**

#### **3.1 Introduction**

This chapter outlines and justifies the research methodology that was employed during the study. The research study was guided mainly by the qualitative research paradigm where the quantitative aspects were also used in data collection and analysis thus a mixed method approach was employed in this study. The methodological design employed in this study was a case study of eighteen ‘A’-Level physics students and six ‘A’ level physics teachers purposively sampled from three high schools in Harare province of Zimbabwe. The interpretive philosophical paradigm was employed during the research study where phenomenology was the guiding perspective. Unlike the naturalistic qualitative paradigm the progressive one was the guiding principle in this research. According to Gray (2011:37) a progressive paradigm entails that reality and science are socially constructed such that research must engage in reflexive and self-critical dialogue where aspects of both quantitative and qualitative paradigms must complement each other as the purpose of research is to reveal hidden realities. The research methodology chapter is sub-divided into nine sections that include:

- Methodology,
- Research design,
- Population and sample,
- Research tools and instruments,
- Procedure for data collection,
- Data analysis procedures,
- Limitations of the study,
- Validity and reliability issues, and
- Ethical issues.

#### **3.2 Methodology**

The qualitative research methodology was predominantly employed in this study where also quantitative techniques in data collection and analysis were also used, entailing a mixed methods approach. Gray (2011:166) defines qualitative research as an approach that seeks to understand phenomena within its contextual specific settings and uses various theoretical stances and methods including the use of interviews, observations, questionnaires and document analysis. De Vaus

(2008:223) defines qualitative research as an in-depth study of situation or phenomena where often participant observation and in-depth interviews are common. The justification for using this methodology mainly is that it combines several strategies and methods within a research design. In this study where the researcher is trying to establish the influence of practical work assessment method on skill development of ‘A’ level physics students the qualitative paradigm will be useful in trying to “see truth and meaning as constructed and interpreted by individuals” as Gray (2011:203) puts it across. This was done through observing students doing practical work as well as triangulating with some open ended interviews with physics teachers as well as focus group discussion with the students. Porta and Keating (2008:227) also note that qualitative researchers tend to analyse their data inductively and theory developed is bottom up. This paradigm becomes very useful in this study as the researcher will then develop a model of practical work assessment as an alternative to practical work examinations. According to Yin (2006:36) qualitative research paradigm requires the researcher to “approach the world with the assumption that nothing is trivial and that everything has the potential of being a clue to unlock a more comprehensive understanding of what is being studied.” This was the guided principle in advocating for embedded multiple case study design to get information from different sources that includes ‘A’-level physics students, physics teachers and document analysis. Quantitative research uses measurable data to formulate facts and uncover patterns. Quantitative data is often structured. It was necessary in this research study to collect quantitative data using a structured observation schedule and then use correlation analysis to compare students’ grades from DAPS and IAPS.

### **3.2.1 The mixed methods approach**

Data collected from the observation schedule was analysed quantitatively. Correlation analysis was employed to analyse quantitative data from the marks obtained from DAPS and those from IAPS. Qualitative data was obtained from interviews with physics teachers as well as focus group discussions with ‘A’ Level physics students. Both narrative and conservation analysis were used to analyse qualitative data. The study therefore employed the mixed methods approach. Creswell and Clark (2007:212) defines the mixed methods approach as “collection or analysis of both quantitative or qualitative data in a single study in which the data are collected concurrently or sequentially, are given a priority, and involve the integration of data at one or more stages in the process of research”. Gray (2011:199) observes that mixed methods designs are those that include at least one quantitative and one qualitative method where neither type of method is inherently linked to any particular inquiry paradigm.

The philosophy of mixed methods research according to Johnson et al. (2007:114) adopts a pragmatic approach based on the view that knowledge is both socially constructed and based upon the reality of

the world we experience and live in. Mixing can occur at various stages and in the case under study mixing occurred at both data collection and analysis stages where grades obtained by ‘A’-Level physics students during practical sessions were correlated with marks obtained from a submitted practical work report. Considering that some of the data were obtained from interviews, this resulted in two types of data analysis, which are statistical and thematic. Conclusions from these findings were subjected to both objective and subjective interpretations.

Gray (2011:213) identifies the rationale for mixed methods as that, one method can deepen and validate the other and also argues that, historically triangulation is the root of mixed method research. The other benefit is complementarity in measuring overlapping but different elements of phenomenon. In the case under study the observation schedule was useful in determining physics students’ practical skills whereas interviews were necessary in getting students’ perceptions on skill development. Gray (2011:214) identifies the major weakness of the mixed method approach as that of bias towards one type of interpretation. Sarantakos (2013:54) notes that the mixed methods approach provide researchers with ways to improve the capacity of their methods and enrich the quality of their findings, their validity, flexibility, credibility, complementarity, generalizability and popularity. Despite advantages associated with the mixed method approach there are some disadvantages in terms of methodological discourse. According to Sarantakos (2013:56) the major weaknesses is related to incompatibilities of the ontology, epistemology, methodology, paradigm and ideology of qualitative and quantitative research which cannot lead to valid and acceptable research outcomes.

According to Sarantakos (2013:50) whilst mixed method is a procedure that employs both qualitative and quantitative methods and strategies in the same project, mixing does not alter the structure and identity of each methodology. Each methodology acts as guided by its epistemology and as employed when used alone.

Strict and rigid adherence to any method, technique or doctrine position may for the researcher become like confinement in a cage. The use of both quantitative and qualitative approaches was quite healthy in this research study. The use of the mixed methods approach ensured validity and reliability in both data gathering and interpretation.

### **3.2.2 Convergent - Parallel Mixed method Approach**

Creswell (2014:219) identifies three types of mixed methods design which are:

- Convergent parallel mixed methods design.
- Explanatory sequential mixed methods design.
- Exploratory sequential mixed methods design.

Explanatory sequential mixed methods design involves the collection and analysis of quantitative data with a follow up of collection and analysis of qualitative data to come up with meaningful interpretation. Exploratory sequential mixed methods design according to Creswell (2014:220) involves the collection and analysis of qualitative data which builds to quantitative data analysis. In this study the convergent parallel mixed methods design was employed. Basically, the design entails the collection and analysis of both quantitative and qualitative data which is then interpreted separately where comparisons may be done to establish any relationships of conformity or disconformity. According to Creswell (2014:219) the assumption of this approach is that both qualitative and quantitative data provide different types of information. It means that detailed views of participants qualitatively and scores on instrument should yield results that are comparable. In this study quantitative data was obtained through the use of the grade obtained by the student using the structured observation schedule for direct assessment of practical work skills which was correlated with the mark obtained by the same student from the marked practical work report. Qualitative data were obtained from interviews administered to both physics teachers and ‘A’ level physics students to get their views on how practical work assessment method influence the practical work skills that can be mastered by ‘A’ level physics students.

### **3.2.3 Research Paradigm: The qualitative aspect of the mixed methods approach.**

An interpretive qualitative paradigm was the major philosophical underpinning of the qualitative aspect of the research study. Gray (2011:21) calls it interpretivism. According to this perspective, interpretive studies seek to explore people’s experiences and views and are inductive in nature. According to Gray (2011:21) the perspective argues that, the world is interpreted through the classification of schemas of the mind. Natural reality (laws of science) and social reality are different and therefore require different kinds of methods with natural sciences looking at consistencies in order to deduce laws (nomothetic) and social sciences dealing with actions of individuals (ideographic) as observed by Yin (2006), Creswell (2007), De Vaus (2008) and Gray (2011). The philosophical perspective advocates for interpretive understanding of human interaction. This philosophy is useful in the study as the influence of the assessment method on skill development of ‘A’- Level physics students can only be better understood through interacting with these students getting insights into their practical work activities as well as observing them carrying out physics practical work activities.

The qualitative aspect of this mixed methods design was guided by an interpretive qualitative paradigm where phenomenology was the guiding approach. Phenomenologists according to Gray (2011:22) hold the view that any attempt to understand social reality has to be grounded in people’s experiences within that social reality. Marshall and Rossman (2006:98) advise that guided by this

approach the researcher needs to approach the field with a neutral, fair and investigative mind. Phenomenologists believe that multiple ways of interpreting experiences are available to each of us through interacting with others. Reality is socially constructed. According to Gray (2011:171) phenomenologists argue that the relation between perception and objects is not passive as human consciousness actively constructs the world as well as perceiving it. It was necessary for the researcher to gain access to ‘A’ –level physics students through observing and assessing them doing practical work as well as interviewing teachers and students in order to interpret and understand their action as phenomenology seeks to understand the world from the participants’ point of view. The meaning people give to their experience and their process of interpretation are essential and constructive as individuals construct meaning according to Gray (2011:22). This is the same philosophy that motivated the researcher to do interviews to ‘A’-level physics students and physics teachers than simply relying on the correlation analysis of grades obtained from observing students doing practical work against the grade obtained by student after marking the submitted report in order to get deeper insights on the practical work skills students develop during practical sessions. Gray (2011:22) sees phenomenology as an exploration via personal experience where attempts are made to avoid ways in which biased data can be collected. The basic beliefs of phenomenologists are that the world is socially constructed and science is driven by human interest and that the researcher should focus on meanings and models from data, through the use of multiple qualitative methods of data collection on a small sample which is studied at depth, according to Yin (2006), Creswell (2007) and Gray (2011). This is the philosophical perspective that guided the researcher in data collection and analysis.

### **3.3 Research Design**

De Vaus (2008:9) defines a research design as a “work plan or structure before data collection or analysis can commence including population sample, methods of data collection and analysis”. From this definition, a research design is a logical structure of the inquiry. It deals with a logical problem by ensuring that the evidence obtained enables us to answer the research questions. A case study design was employed in this research using a mixed methods system in recognition of the fact that both qualitative and quantitative methods may have limitations where one may neutralise the limitations and biases of the other.

According to Porta and Keating (2008:226), the word case is derived from the Latin word “Casus” meaning occurrence or something that happens usually with unfavourable connotation. A case therefore requires a solution. Porta and Keating (2008:226) defines a case study as a “research strategy based on the in-depth empirical investigation of one or a small number of phenomena in order to explore the configuration of each case and elucidate features of a larger class of similar

phenomena". De Vaus (2008:220) defines a case as the object of study... a unit of analysis about which you collect information...a unit that we seek to understand a whole". A case study seeks to build up a full picture of a case, its sub units and its context. Case studies can be used to develop and evaluate theories as well as formulate hypotheses or explain a particular phenomenon according to Porta and Keating (2008:227).

A case study approach was used to explain phenomena of practical work assessment and trying to come up with an alternative model of 'A'-level physics practical work assessment. The case study focused on the identification of assessment practices currently used by 'A' level physics teachers and the practical work skills that are exhibited by 'A' level physics students during practical work sessions. Views of the physics teachers were also important in determining how the assessment methods employed by 'A' level physics teachers influence the development of practical work skills of their students. A multiple case study approach with an ultimate goal of theory building was employed in this study. This was done through purposively sampling of three high schools with 'A' level physics students of different economic and social backgrounds. Six students from each school type participated in the study. Gray (2011:257) call this 'multiple case- embedded' where in my research study, data obtained from different sources were collected from three different schools of socio-economic background in Harare province of Zimbabwe.

A multiple case design was used in this study because "multiple case designs are normally powerful, convincing and provide insights than single case designs" according to De Vaus (2008:228). The unit of a single case which in this study was 'assessment method' was respected and replicated across the three schools purposively sampled for the study. A well designed case study will build a picture of a case by taking into account information gained from many levels, according to De Vaus (2008). In this study information was obtained from physics teachers, individual 'A'-level physics students and focus group discussions. The final case study will tell more than any constituent element of case will do. There are quite number of advantages associated with case study designs:

- Any method of data collection can be used within a case study design so long as it is practical and ethical.
- Case study designs are particularly useful when we are unable to screen out the influence of external variables (De Vaus, 2008:232).
- Data can be collected in various ways and it can be both qualitative and quantitative.
- On data analysis case studies can be combined with other methods like statistical analysis (Porta and Keating, 200:226).

- Data can easily be triangulated to balance out any potential weaknesses in each data collection method.
- Case studies allow for generation of multiple perspectives (Gray, 2011:170).

Gray (2011:170) advises of questions to consider when using a case study research design:

- What is the unit of analysis? For example, individuals, organisations.
- What criteria are to be used to select cases for the study?
- Who are the participants?
- How many cases are there and how many participants within each case?

The framework of the research design was guided by these questions. The subjects of the study were sixth form physics students and six physics teachers sampled from three high schools in Harare Province of Zimbabwe. The population consisted of all sixth form physics students and teachers in Harare province. Purposive sampling technique was used to select the three schools, where one private school, one former group A school, and one former group B school were chosen. Three instruments were used to collect data, namely the observation schedule, interview schedule and focus group discussion schedule. Correlation analyses was used in data analysis where Pearson's correlation coefficient ( $r$ ) was calculated from marks awarded by physics teachers on the submitted practical report and marks from an observational scale used by the researcher during practical sessions. This data was also compared with results obtained from the interviews by physics teachers and focus group discussions with sixth form physics students as guided by the convergent-parallel mixed method approach. The discussion was based on obtained results and appropriate conclusions were drawn and recommendations made.

### **3.4 Population and Sample**

The population consisted of all 'A'-level physics students and teachers in Harare province. A total of three schools, eighteen physics students and six physics teachers participated in the study. Purposive stratified sampling was used to select the schools where one high school from low density suburbs (former group A school), one high school from high density suburbs (former group B school) and one private school (registered with the ministry of primary and secondary education) from greater Harare area participated in the study. The reason for using purposive stratified sampling technique was to ensure that all school types could equally be presented in the sample. Gray (2011:152) argues that this sampling technique is important if one has to minimise bias in sample selection or omitting vital characteristic. By using this sampling technique, the researcher deliberately selected the subjects against one or more trait to give representative sample.

Convenience sampling technique was used to select the six students from each of the three participating schools where three boys and three girls were selected for participation basing on the strategy that the first three girls and boys to enter the physics laboratory were considered. The upper sixth students were preferred to the lower sixth since at the time of research as the upper sixth students were at least one year into the ‘A’ level system and were expected to have done a number of physics practicals. Two ‘A’ Level physics teachers participated from each school. Table 3.1 gives a sample of the multiple case studies.

Table 3.1 Sample of multiple case studies

School	Type of school	Number of students observed during practical sessions	Number of practical sessions observed at the school	Number of teachers interviewed per school	Number of students in Focus Group Discussions (FGD)
A	Private	6	2 (one mechanics one electricity)	2 (one taking lower sixth students and one taking upper sixth students)	12 (whole class)
B	Former Group A	6	2 (one mechanics one electricity)	2 (one taking lower sixth students and one taking upper sixth students)	14 (whole class)
C	Former Group B	6	2 (one mechanics one electricity)	2 (one taking lower sixth students and one taking upper sixth students)	10 (whole class)

### 3.4.1 The research instrument

Three tools of data collection; namely the observation schedule, interview schedule and the Focus Group Discussion schedule were employed during data gathering.

### 3.4.2 Observation Schedule

An observation schedule designed following the guidelines from the Practical Skill Handbook for GCE Physics (2010) and Zimsec physics syllabus (9198) of 2013 was the main instrument used to collect data on the three skills under investigation as shown in table 3.2.

Table 3.2 Mastery of practical skills as observed by the researcher(s) during practical session and the grade obtained from the submitted report

Skill	Comments and rating as observed by the researcher on score range 0-10	Obtained Mark from the submitted report by the student and comments of the teacher
A	<b>Manipulative Area</b>	
	A1 Manipulate effectively standard laboratory equipment	
	A2 Set up and use effectively the apparatus relevant to an experiment	
	A3 Work accurately, systematically and with reasonable speed	
	Score range(0-10)	
B	<b>Observational</b>	
	B1 Observe accurately.	
	B2 Record observations accurately.	
	B3 Read instruments correctly	
	Score range (0-10)	
C	<b>Planning /Designing</b>	
	C1 Plan an experimental procedure, applying standard laboratory techniques	
	C2 Modify established techniques to suit novel experimental situations	
	Score range (0-10)	

	Percentage average score on skill mastery as observed by the researcher		Percentage average score from the submitted marked report	
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Porta and Keating (2008:98) note that observation entails the systematic noting and recording of events, behaviours and artefacts in social setting chosen for the study. It involves concrete descriptions of what has been observed. Gray (2011:397) defines observation as involving systematic viewing of people's actions and the recording, analysis and interpretation of their behaviour. In this study, for ethical reasons, observation was conducted with the knowledge of those being observed and Gray (2011) refers to this type of observation as overt observation. It was important to build a good rapport with the physics students and teachers. Gray (2011:412) advises of the need to be honest, friendly and open. As a science educator, the researcher did not face problems on this aspect. Preliminary visits were done to the sampled schools where the researcher explained the purpose of his study to both physics teachers and students and on the day of doing experiments, the subjects were aware of the impending visit. This was important to get acquainted with the target group and drawing up first impressions and points of reference.

A letter from the ministry of primary and secondary education giving the researcher permission to carry out the study in the province was shown to the school head, physics teachers and students. The participants were also served with a letter to the school heads requesting permission to conduct research at the school (see appendix 5). In addition to this the participants were also served with an information letter detailing the purpose of the research (see appendix 6) during the preliminary visit. Participants were also requested to sign the consent form before taking part in the study (see appendix 7) and those below the age of eighteen years were served with a letter requesting parental consent for participation in the research study (see appendix 8).

Structured observation was used in this study where an observation schedule was used to assess the skills of the physics students as they were doing practical work activities as well as analysing marked practical work reports by the teacher after the practical work session. It must be noted here that structured observation is more quantitative in nature. Gray (2011:407) identifies a number of advantages of using structured observation including that:

- It results in more reliable data because the results can be replicated either by the researcher at a different time, or by other researchers,
- It allows data to be collected at the time they occur and does not have to rely on the recall of participants or their interpretation of events, and

- It collects data that participants themselves may not realise are important.

Gray (2011:407) identifies two disadvantages that:

- The researcher must be at the place where the events are occurring and at the appropriate time.
- Only overt actions can be observed, from which often subtle inferences have to be made.

Observation is fundamental and highly important method in all qualitative inquiry. Porta and Keating (2008:99) identify the challenge of observation on the difficulty of managing a relatively unobtrusive role and that of finely observe huge amounts of fast moving and complex behaviour. Yin (2006:86) notes the problem of reflexivity where an event may proceed differently because it is being observed. De Vaus (2008:83) talks of the problem of “*self-fulfilling prophecy*” as result of the fact that the researcher’s expectations and values will inadvertently distort the way he or she collects and interpret information as one’s expectation can affect what he or she sees. De Vaus (2008:83) advises on the use of multiple “*judges*” and observers so that different observers can act as a check on one another.

It is against this background that the researcher decided to use two research assistants during data collection. Instead of engaging ‘A’-level physics teachers at that particular school where observations were done, the researcher made use of two colleagues in the field of physics education who are lecturers at Bindura University. This was a deliberate move to minimise bias if physics teachers at that school were used as they had inside information on the performance of the students. The research assistants had vast experience of teaching ‘A’-level physics as well as marking Zimsec practical examinations before joining the university. The researcher and the two research assistants observed two students each per school during practical sessions, rating them using the observation schedule in table 3.2. Two practical sessions were observed at the three sampled schools giving a total of thirty six completed observation schedules considering that six students per school were observed for each practical session.

The observation schedule assisted in answering mainly research questions one and two. The following explains how this was achieved.

*Research question 1: How do ‘A’- level physics teachers assess practical work skills of students during the course of their programme?*

This question was addressed through the use of the structured observation schedule where the researcher perused through the marked practical work reports checking on sections students were scored in terms of data presentation, graphical work and data analysis. A summary of the observations was recorded in the observation schedule under the column “Obtained mark from the submitted report by the student and comments by the teacher” (see table 3.2) for each of the six students observed at

each school. During the practical session, the researcher also wanted to observe whether any form of assessment of students' practical work skills was done.

*Research question 2: How relevant are the assessment practices on students' practical skills development?*

This research question was addressed through the use of the observation schedule where the researcher and the two research assistants observed the students' practical work skills and score them out of 10 for each of the four broad skills of manipulation, observation, planning and designing. Each researcher concentrated on just two students during the practical session where finer details on the skills under observation as outlined in appendix 1 were scored on a scale ranging from 0-10. By scoring the students on a scale ranging from 0-10 on each of the skill under observation and then comparing the total score with the mark obtained by the student after the teacher had marked the practical work report, it was possible for the researcher to determine the relevance of the assessment practices on the student's practical skill development.

This section clearly justifies the use of the structured observation schedule in trying to find answers to the research problem and research questions one and two in terms of the way practical work is assessed by physics teachers as well the relevance of the assessment methods employed by physics teachers. It is important to note that this tool alone cannot provide all the answers to the research problem hence the need for triangulation.

### **3.4.3 Interview schedule**

An interview is a conversation between people in which one person has the role of the researcher according to Gray (2011:369). An interview is a powerful tool for obtaining rich data on people's views, attitudes and the meanings that underpin their lives and behaviours. In addition to listening to verbal responses the interviewer may also be noting other elements of the interview process like body language of the interviewee. Meanings can also be clarified during the interview. Gray (2011:370) argues that interviews suits well with phenomenological approach which is concerned with meanings that people ascribe to phenomena.

Open ended interviews were administered to two physics teachers at each sampled school to solicit their views on the way physics practical work is assessed as per Zimsec requirements. The focus of the interview was on:

- the role of the teacher during physics practical work sessions,

- practical work skills that are developed by students during practical sessions,
- how these skills are assessed, and
- perceptions of the physics teachers on the assessment of ‘A’-level physics practical work and their recommendations.

The interview schedule was developed in three stages. The first draft of the interview schedule was pilot tested to three physics teachers from a chosen school outside the sample. The researcher then asked the teachers to comment on issues of clarity on the questions in the process ensuring content validity. Changes to question phrasing and content were made in response to suggestions given. The main objective of the pilot phase was to increase the validity of the instruments in terms of language, assessment of practical work skills and time of interview. The pilot study was also intended to find out whether respondents were able to understand the questions. Internal reliability of the instrument was checked by verifying consistency of the responses and ensuring that respondents answered related items in a similar way. The pilot phase was instrumental in improving the validity and practicality of data collection instruments through generating valuable suggestions for improvement.

The resulting draft was then sent to the supervisor for further editing. The final draft was then administered to six physics teachers from the sampled schools. Interviews were audio recorded with the permission of interviewees and were designed to last thirty minutes. The recordings were later transcribed for analysis purposes. Interview data were analysed qualitatively with verbatim comments being used to illustrate certain issues as they emerged. Structured interviews were preferred as a method of data collection for a number of reasons:

- Interviews are insightful as they provide perceived causal inferences (Yin, 2006:86),
- Interviews yield data in quantity quickly,
- Immediate follow ups and clarifications are possible,
- Combined with observation, interviews allow the researcher to understand the meanings that everyday activities hold for people.(Marshall and Rossman, 2006:102), and
- Provide original and illuminating data (Gray, 2011:259).

There are however some disadvantages associated with interviews, which include:

- danger of bias due to poorly constructed questions,
- response bias,
- reflexivity where interviewee gives what the interviewer wants to hear.(Yin,2006:86 and Gray 2011:259),

- interviewee maybe unwilling or uncomfortable sharing all that the interviewer hopes to explore, and
- it requires good interviewing skills (Marshall and Rossman, 2006:102).

One way of validating interviews is to compare the interview measure with another measure that has already been shown to be valid. Cohen, Manion and Morrison (2011:207) call this convergent validity. In this research study, information obtained from interviews was compared also with that obtained from the structured observation schedule and focus group discussion. Validity was also ensured during interview sessions by maintaining the same wording and sequencing of questions. Cohen, Manion and Morrison (2011:207) identify five ways in which validity is ensured during interviews:

- Establishing trust.
- Pitching questions at the right level.
- Keeping to the point.
- Being clear in terminology and coverage of material.
- Being sensitive and emphatic, using active listening and being sensitive to how something is said and the non-verbal communication.

Generally, this technique proved to be very useful as a tool for data collection. It assisted in answering research questions one, two and three.

*Research Question 1: How do ‘A’- level physics teachers assess practical work skills of students during the course of their programme?*

The structured interview administered to two ‘A’ level physics teachers at each of the sampled schools was vital in addressing this research question. This research question was addressed through asking questions on how physics teachers assess students’ practical work skills during and after the practical work session (refer to questions 4, 5 and 8 of appendix 2). Teachers were also asked questions on the level of assistance they gave to the students during practical work sessions and how this impacted on their final assessment of ‘A’ level physics students’ practical work skills. The researcher also wanted to find out from the physics teachers whether Zimsec prescribed the method of practical work assessment to schools or whether the assessment of practical work used by Zimsec in the final examination forced teachers to employ the same methods of assessment during the two year ‘A’ level course.

*Research question 2: How relevant are the assessment practices on students’ practical skills development?*

This research question was addressed through interview questions 6,7,8,9 and 10 from the interview schedule (refer to appendix 2). The researcher wanted the views of the physics teachers on the relevance of the Zimsec's prescription of practical work assessment in developing practical work skills of 'A' level physics students. The challenges teachers face with Zimsec's assessment of physics practical work was also interrogated. The researcher also wanted to find out from the physics teachers the reasons for not assessing students as they carried out practical work activities rather than simply relying on the submitted practical work report as the basis of their assessment. This was necessary to find out from the physics teachers whether the current way of practical work assessment assisted students in developing practical work skills.

*Research question 3: What are the possible alternatives to physics practical work examinations?*

This research question solicited for physics teachers' views on the alternative methods that can be used in the assessment of physics practical work in view of the challenges they would have highlighted using the current method of practical work assessment. This research question was addressed by interview questions 11, 12 and 13 on the interview schedule (refer to appendix 2). Physics teachers' views were important in developing a new model of practical work assessment with the possibility to replace in part or in full the current practices of practical work assessment by Zimsec.

#### **3.4.4 Focus Group Discussions**

Focus group discussion was used as the third tool of data collection. These discussions were done by upper sixth physics students at each sampled school where the researcher chaired the sessions assisted by the two research assistants. The focus of the discussions was on issues to do with:

- the role of the teacher during physics practical work sessions,
- practical work skills that are developed by students during practical sessions,
- how these skills are assessed,
- relevance of practical work assessment, and
- Perceptions of the students on the assessment of 'A'-level physics practical work and their recommendations.

'A' level physics classes in Zimbabwe are not all that large – for they are normally composed of no more than ten students per class. The small sizes of the classes facilitate for active participation for all students during focus group discussions. According to Gray (2011:389), Focus Group Discussions require considerable amount of cooperation and enthusiasm from the participants. This is the reason why these were done at the end when the subjects were now used to the researchers thus were more

confident and could easily open up as they had built a good rapport with the researcher. Gray (2011:389) notes that, when researcher is running a Focus Group Discussion, he or she must be prepared for unexpected comments and expression of views which might be unhelpful or distasteful. Gray (2011:389) advises of the need to remain calm and neutral. The Focus Group Discussions (FGDs) were useful in triangulating data collected from interviews and the observation schedule. The Focus Group Discussions (FGDs) assisted in answering research questions one, two and three.

*Research Question 1: How do ‘A’- level physics teachers assess practical work skills of students during the course of their programme?*

As way of triangulating and validating the information obtained through administering interviews to ‘A’ level physics teachers, it was important to get the opinion of the students on the assessment of physics practical work skills. The focus group discussion questions addressing research question one solicited for students’ views on the assistance they get from physics teachers and how this impacted on the assessment of their practical skills by the teacher. Students were also asked to comment on the way practical work is assessed. The researcher also asked students about the practical work skills which they thought were important to pass examination and how these skills were assessed. In a nutshell, focus group discussion questions 1, 2, 3 and 4 assisted in addressing issues raised by research question 1 (refer to appendix 3).

*Research question 2: How relevant are the assessment practices on students’ practical skills development?*

This research question was addressed by focus group discussion questions 4, 5 and 6 (refer to appendix 3). The focus group discussion questions solicited for students’ views on whether it was possible to pass practical work because of good presentation skills though they would have failed to do the correct procedures during practical work session. In other words the researcher wanted to find out from the students’ experiences, the possibility of cheating where a candidate can “cook” the values and still pass because of good presentation skills. The researcher also wanted to find out from the students the envisaged advantages and disadvantages of both direct and indirect assessment of ‘A’ level physics practical work. The information obtained was audio recorded.

*Research question 3: What are the possible alternatives to physics practical work examinations?*

This research question was addressed by focus group discussion questions 5, 6 and 7 (refer to appendix 3). The research question solicits for ‘A’ level physics students’ views on the alternative methods of physics practical work assessment, stating the advantages and disadvantages of the alternative model. Students were free to express their opinions as the physics teachers were not present during the discussion. The researcher also wanted to get the students’ views on the changes

they might want on the structure of the syllabus especially on issues to do with the assessment of practical work. To a large extent, the focus group discussion assisted in addressing concerns of research question 3 because of the various views expressed by ‘A’ level physics students some of which were debated among students. Some of the issues could not have been highlighted in a case of one to one interview with a student. This is so because new or alternative thinking can be triggered by an opinion which could have been raised by another subject.

### **3.5 Procedure for data collection**

The main instrument for data collection was the structured observation schedule as outlined in table 3.2. This was complimented with interview schedule and focus group discussions. A preliminary visit to the three sampled schools was done two weeks in advance before data were collected to work out the modalities and logistics with relevant school authorities. The purpose of the visits was to arrange for dates and times for practical sessions at a particular sampled school. Gray (2011:409) identifies one of the greatest problems with observational method as getting into the research setting and emphasises the importance of building a working relationship with individuals who play a key role in either granting or denying access. The preliminary visit to the schools played this crucial role. A letter from the ministry of primary and secondary education granting the researcher permission to carry out the research study in Harare province was presented to the school authorities during the preliminary visit. The researcher had an opportunity to talk to the ‘A’-level physics teachers and students during this preliminary visit, explaining to them the purpose of the study and agreeing on the dates times when data were going to be collected. Informing people in the research setting of what you are doing and eliciting their consent is seen as a good practice by Gray (2011:411). The school heads were also served with a letter that explained the purpose of the research, how the school was selected and the envisaged benefits of participating in the study (refer to appendix 5). The physics teachers and students were also served with an information letter detailing the purpose of the study, type of research instruments that were going to be administered to them as well as anticipated benefits of the study (refer to appendix 6). Participants were also requested to sign a consent form before taking part in the study (refer to appendices 7 and 8).

After the first visit to the schools, two practical sessions were observed in succession during the second and third visit to the schools where data were gathered using the structured observation schedule as outlined in table 3.2. The researcher was assisted by two research assistants to do the observations to six ‘A’ level physics students at each school during the practical sessions. Each researcher at a particular school was assigned to two physics students. The fourth visit was done to obtain marks scored by the observed students from the submitted practical report which was marked

by the physics teacher. During the same visit the researcher had a chance to carry out interviews to the physics teachers as well as doing some focus group discussions with the ‘A’-level physics students.

The interviews helped the researcher in getting some in-depth responses and reactions from both ‘A’-level physics students and teachers .The subjects had a chance to explain and express their feelings about skill development considering the current way ‘A’- level physics practical work is being assessed. This could not however be obtained from the observation schedule. The carrying out of interviews and focus group discussion during the fourth and last visit to the school was a deliberate move as the atmosphere between the researcher and the respondents was more relaxed due to familiarity. This enabled the respondents to answer questions without fear or suspicion thus helping in obtaining fairly reliable information. According to Gray (2011) the researchers may become “*invisible*” due to length of time they are involved with the subjects. Invisibility means that the participants cease to be consciously aware of the researcher’s presence therefore act more naturally. This was the reason why the researcher collected data in four phases at each school as the subjects became more accustomed to the researcher.

### **3.6 Data analysis and interpretation**

Data analysis can be referred to as the conversion of raw data into useful information that will provide the most value to researchers according to Jupp (2006:161). The data of scores of students from structured observation schedule as well as marks from the practical work reports were entered into a statistical software SPSS version 22. Measures of relationship such as scatter plot and correlation coefficient were used to determine the nature and extent of the relationship between scores of students from both DAPS and IAPS. Correlation analysis was used to analyse data obtained using the structured observation schedule. A Scatter diagram was drawn to establish any correlation between two sets of marks for the same experiment assessed using DAPS and IAPS. Pearson Correlation( $r$ ) was calculated to investigate the relationship between rating as observed by the researcher (DAPS) and obtained mark from the submitted practical work report (IAPS).

Conservation analysis was employed on transcribed data from interviews administered to ‘A’- level physics teachers. Conservation analysis according to Gray (2011:514) is interested in the formal analysis of everyday conservations including the analysis of natural texts and seeks to specify the formal principles and mechanisms with which participants express them in social interactions. Narrative analysis (Creswell, 2007) was used to analyse data from focus group discussions with ‘A’-level physics students.

### **3.7 Limitations of the study**

- Only urban schools in Harare province were conveniently sampled for the research study. At least one rural high school could have been necessary for variations.
- Though the research assistants were important for internally validating the observational data, this may have been problematic in a situation where some assessors are generally mean while others are naturally generous.
- Problem of generalizability of the research findings though the qualitative paradigm argues for theoretical generalisation.
- Bias towards one interpretation could be problem, considering results from the structured observation schedule (which were analysed quantitatively) as compared to those from interviews and focus group discussions (which were analysed qualitatively).

#### **3.7.1 Validity and Reliability**

Validity refers to the extent to which descriptions of events accurately captures those events. It has to do with the truthfulness and trustworthiness of data. According to Neuman (2011:208), validity suggests truthfulness and refers to how well an idea fits with actual reality. Cohen, Manion and Morrison (2011:179) suggest that in qualitative data validity might be addressed through the honesty, depth and richness of data, the participants approached, the extent of triangulation and disinterestedness or objectivity of researcher while in quantitative data validity might be improved through careful sampling, appropriate instrumentation and appropriate treatment of the data. Neuman (2011:211) warns that validity is more difficult to achieve than reliability thus we cannot have absolute confidence about validity. De Vaus (2008:28) notes that the researcher needs to satisfy themselves if indeed the research design did deliver the expected conclusions as determined.

In qualitative studies, we are more interested in achieving authenticity than realising a single version of truth. According to Neuman (2011:214) authenticity means offering a fair, honest and balanced account of events from the viewpoint of participants. In order to achieve some degree of validity, there is need for rigour. According to Cohen, Manion and Morrison (2011:181) rigour can be achieved by careful audit of trials of evidence, peer debriefing, negative case analysis and triangulation. There are different forms of validity but in this research issues on internal and external validity were of concern.

In mixed methods research paradigm, Cohen, Manion and Morrison (2011:198) argue for the use of the term legitimization instead of validity. This is achieved by ensuring that the results are dependable, credible, transferable, plausible, confirmable and trustworthy. Onwuegbuzie and Johnson (2006:57) identify some types of legitimization in mixed methods research which are:

- Sample integration (how far different kinds and size of sample in combination, or the same samples in quantitative and qualitative research can enable high quality inferences to be made). Despite employing the case study methodology in this research where only three schools were sampled, quantitative aspects were employed on data gathering from the observation schedule where a total of 36 experimental observations were done in order to employ inferential statistics on data analysis.
- Weakness minimisation (how far any weaknesses that stem from one approach ,are compensated by the strengths of the other approach, together with suitability weighting such as strengths and weaknesses).
- Conversion (how far qualitising numerical data or quantising qualitative data can assist in yielding robust ‘meta-inferences’).
- Paradigmatic mixing (how successful is the combination of the ontological, epistemological, axiological, methodological and rhetorical beliefs and practices in yielding useful results, particularly if the paradigms are in tension with each other).
- Political (how accepted by the audiences are the ‘meta-inferences’ stemming from the combination of quantitative and qualitative methods).

Validity was basically improved through the use of different methods of data collection where an observation schedule, interviews and focus group discussions were employed during data collection. The use of multiple cases was important in legitimising the results of the study. Pilot testing of instruments was also done as means of minimising any ambiguities and logistical problems that could have been experienced during data collection. The use of research assistants was a deliberate move of addressing issues of validity as the research assistants acted as moderators during data collection using the structured observation schedule. The sequence in which data were collected where at least four visits were made to each school was a way of increasing familiarity with the subjects also contributed significantly in obtaining valid information.

Reliability refers the consistency of measurement. Reliability does not assure validity. Reliability means dependability or consistency according to Neuman (2011:208). Cohen, Manion and Morrison (2011:199) define reliability as essentially a synonym for dependability, consistency and replicability over time, over instruments and over groups of respondents. It suggests that the same thing is repeated or recurs under the identical or very similar conditions. Reliability therefore is concerned with precision and accuracy. Cohen, Manion and Morrison (2011:200) argue that, a reliable instrument for a piece of research will yield similar data from similar respondents over time. According to Yin (2006:39), if a later investigator follows the same procedure as described by an

earlier investigator and conducted the same case study the later investigator should arrive at the same findings and conclusions.

Neuman (2011:208) defines representative reliability as reliability across subpopulations, different cases or different groups. In this study representative reliability was catered for through purposively selecting three schools of different social and economic background. Due care was also taken to have balanced participation by the subjects by gender at the three schools where the research was carried out .Equivalence reliability can be achieved if consistency is observed in a case where equivalent forms of data gathering instrument is used according to Cohen, Manion and Morrison (2011:200) . In the case under study, this type of reliability was catered for from the similarity of some questions administered in the interview schedule and those for the focus group discussion to find out on the consistency of responses.

In qualitative research the term reliability is often replaced by such terms as credibility, dependability, or confirmability according to Cohen, Manion and Morrison (2011:201). Qualitative research can address reliability in part by asking three questions particularly in observational research according to Cohen, Manion and Morrison (2011:203), which are:

- Would the same observations and interpretations have been made if observations had been conducted at different times? (The stability version of reliability).
- Would the same observations and interpretations have been made if other observations have been conducted at a time? (The parallel forms version of reliability).
- Would another observer working in the same theoretical framework, have made the same observations and interpretations (the ‘inter-rater’ version of reliability).

These questions proved to be very crucial during data gathering through triangulation of observations made by the researcher and those from research assistants on the same advanced level physics student during practical sessions. The use of the structured observational schedule was a deliberate move of ensuring that the data collected were at least reliable as it checks on consistency in data gathering. The structured observational schedule ensures that the observer enter data into appropriate categories consistently and accurately according to Cohen, Manion and Morrison (2011:203). Reliability can also be at least ensured through the use of a range of data sources and employ multiple measurement methods according to Neuman (2011:214). This is the reason why focus group discussion and interviews were used in addition to the observation schedule. Subjects of the study were almost half way through their course when the study was conducted as this catered for the stability version of reliability.

The use of the two research assistants catered for the ‘inter-rater’ version of reliability. In qualitative research it is acceptable that different researchers who use alternative measures may find distinctive results as data collected is an interactive process as noted by Neuman (2011). Gray (2011:193) observes that the reliability of findings can be improved by triangulation, gathering information from multiple sources and using multiple data gathering tools. The use of multiple case studies where different data gathering tools were used was a deliberate move to improve reliability. Gray (2011:193) identifies four kinds of triangulation namely:

- Data triangulation where data are gathered using multiple sampling strategies. This also included person triangulation where data were collected at different levels that included the physics teacher, individual students and focus group discussions where the whole group was considered.
- Investigator triangulation where more than one observer in the field is used. In this research, two research assistants were used to collect data using the structured observation schedule. This is important as it improves what Gray (2011) calls ‘inter-judge reliability’. Observer bias was also reduced.
- Multiple triangulations in which a combination of multiple methods, data types and observers are combined in the same investigation. In this research both qualitative and quantitative methods of data collection and analysis were used. Information was obtained from three sources namely structured observation schedule, interviews and Focus Group Discussions (FGDs).
- Methodological triangulation where a researcher employs varieties of data gathering techniques within the same or between methods. This was the case during the current research where the mixed methods approach was employed in both data collection and analysis.

Reliability was also improved through the use of pre-designed observation schedule which was partly adapted from the Practical Skill Handbook for GCE Physics (2010).

### **3.7.2 External Validity**

According to de Vaus (2008) external validity is concerned with the extent to which results from the study can be generalised beyond a particular study. Where as in quantitative research, results may lack external validity because they cannot be statistically generalised, in qualitative paradigm the results can however be theoretically generalised. According to DeVaus (2008:233), theoretical generalisation involves generalisation from a study to a theory. Yin (2006:37) talks of analytical generalisation where the investigator is striving to generalise a particular set of results to some broader theory. In this theory building case study, data were collected from only three schools to find out on the

influence of practical tests on skill development and use the findings to develop an alternative model of practical work assessment. External validity was also ensured through the use of different data gathering and presentation methods which were both quantitative and qualitative. In other words different types of cases under different conditions were examined using different data gathering methods. According to De Vaus (2008:234), the external validity of case studies is enhanced by strategic selection of cases rather than statistical selection. Three schools of different socio-economic background were purposively selected in this study to cater for socio-economic differences within schools that may have an impact on resource availability.

According to Gray (2011:191) external validity is concerned with the extent to which it is possible to generalise from the data to other cases or situations. Unlike the statistical or nomothic generalisation, as in positivism, Gray (2011:191) argues that in qualitative research results thrive on naturalistic generalisation which is more intuitive and ideographic but none the less, an empirical approach based upon personal direct experience. Results from individual cases may be used to build a working hypothesis that can be tested in subsequent cases as this was the scenario during this study. External validity was also ensured through the use of purposive sampling to illustrate pertinent issues when comparing contexts for similarity. Thick descriptions of findings were done from data obtained from interviews and observation schedule. Cohen, Manion and Morrison (2011:295) note that whilst case studies may not have external validity checks and balances that other forms of research enjoy, external validity may be catered for through clarifying the contexts, theory and domain to catered for through theoretical framework adopted where a model of practical work assessment was proposed. Neuman (2011:217) argues that, external validity has serious implications for evaluating theory.

### **3.7.3 Internal Validity**

Internal validity is the extent to which the structure of the research design enables us to draw unambiguous conclusions from our results according to De Vaus (2008:10). The research design must sustain the causal conclusions that we claim for. In the current study internal validity was improved through the use of different methods of data collection as well as including research assistants to avoid observer effect thus reducing bias in collecting both qualitative and quantitative data. Triangulation was very useful in ensuring internal validity. This notion of triangulation is supported by Flick (2006), Yin (2006), Porta and Keating (2008), Gray (2011) and Neuman (2011). Flick (2006) observes that the issue of internal validity revolves around the question of how far the constructions of the researcher are grounded in the construction of those being researched. This according to Flick (2006) can be achieved through internal replication by the use of research assistants or other researchers who may inspect the procedures through which the research has been conducted. A verbatim transcription is important in ensuring internal validity according to Gray (2011:190). This

was done for the data which were collected through interviews and focus group discussions. Internal validity may be threatened by extraneous variables which may be overlooked during data collection especially in causal case studies. Cohen, Manion and Morrison (2011:295) in light of this threat observe that internal validity can be ensured through ensuring agreements between different parts of data, matching patterns of results, ensuring that the findings and interpretations derive from data transparently and that causal explanations are supported by evidence. Neuman (2011:217) summarises the importance of internal validity by saying that “... it means we have not made errors internal to the design of research project that might produce false conclusions”.

### **3.8 Ethical issues**

According to Cohen, Manion and Morrison (2011:76) ethics concern the right and wrong, good and bad practices during the research process. One has to consider how the research purposes, contents, methods reporting and outcomes abide by ethical principles and practices. Gray (2011:69) defines ethics as the moral principles guiding research. It entails conducting research in a responsible and morally defensible way. There are quite a number of ethical issues to be considered when carrying out a research project, which includes informed consent, confidentiality, harm and deception.

Cohen, Manion and Morrison (2011:76) note four different views on ethics which are deontological, consequentiality, virtue and situational. Deontological view of ethics concerns what one has duty or obligation to undertake. It involves treating people as ends in themselves rather than means. The argument here is that the ends never justify the means and as such ethical principles should never be compromised. Within the deontological view, Gray (2011:69) identifies two perspectives which are the universalistic and relativistic perspectives. The universalistic position is that rules should never be broken whilst the relativistic position is that rules or duties may vary across different countries, communities or professional groups.

The consequentialist view of ethics concerns the outcomes of actions, for example the utilitarian view that ethical behaviour is that which produces the greatest good for the greatest number. The third view on ethics according to Cohen, Manion and Morrison (2011:76) is the virtue ethics whose basis is that one pressures what is good simply because it is good and right. The last view according to Cohen, Manion and Morrison (2011:77) is situational ethics which is concerned with what we should do or what is right depends on the situation in question. This research study was guided both by the deontological and virtue views on ethics. The main reason for adopting these views was out of the respect of participants' rights as equal partners during the research process. Ethical principles fall into four main areas which according to Gray (2011:73) are:

- Avoiding harm to participants.

- Ensure informed consent of participants.
- Respect of privacy of participants.
- Avoid use of deception.

### **3.8.1 Informed consent**

This is the process in which subjects choose whether to participate in a research study. Participants were asked to fill in a consent form adapted from Gray (2011:393). The consent form (see appendices 7 and 8) in its preamble disclosed the nature and purpose of the research procedures including any risks, anticipated benefits of the research, provision for assuring that subjects understand they may ask questions and, or withdraw from any time from the research, that participants really do understand the implications of the research and rights and obligations to confidentiality. The consent form was completed by both the physics teachers and the ‘A’ level physics students who participated during the research study (refer to appendices 7, 8, 9 and 10).

The researcher also sought permission from the ministry of primary and secondary education (see appendices 3 and 4) to carry out the research study in the sampled schools. The letter from the ministry was used to get entry into the school as it is the law in Zimbabwe that one needs to be cleared first by the relevant ministry before carrying out any research study where teachers and students are involved.

### **3.8.2 Confidentiality**

One way of protecting a participant’s right to privacy is through promise of confidentiality according to Cohen, Manion and Morrison (2011:77). This is done through keeping subjects anonymous. The essence of anonymity is that information provided by subjects should in no way reveal their identity. In this study this ethical issue was observed with the importance it deserves. The research assistants were trained prior to their engagement and were made sensitive to their ethical responsibilities. In the preamble of each research tool used in the subjects were assured that the information collected was for the purpose of the study and that their identities were not going to be revealed. The information collected was safe guarded through the use of codes assigned to individual subjects. These measures to some extent helped in ensuring that participants remained anonymous.

### **3.8.3 Harm**

People must not be physically, psychologically, personally, professionally or emotionally harmed by participating in a research study. It was indeed the responsibility of the researcher in this point in case to protect the participants from any form of harm through phrasing questions in ways that took into cognisance their feelings, morals, attitudes and beliefs. The research team was as also professional in

its contact with the subjects including treating subjects as equal partners during the research process. It must be noted however that, it is difficult to conduct a research that is not harmful as it is quite hard to ensure.

### **3.8.4 Ethics Review Committee**

Getting an approval through an institution ethics committee is important in any research study according to Gray (2011:74). The research tools and abstract of the research proposal were submitted through the supervisor to the ethics review committee for clearance before the researcher embarked on data collection. This was done after the researcher had carefully gone through the UNISA research ethics policy document of 2012 and college of education guidelines for completing the application form of 2014. According to the 2014 college of education ethics clearance template, the research ethics review system at UNISA aims to protect potential human participants, and to contribute to the highest attainable quality of scientific and ethical research. The researcher completed the college of education research ethics review committee application form of 2014. The researcher submitted the following documents to the ethics committee for ethical clearance:

- Appendix 1-structured observation schedule.
- Appendix 2-Interview schedule for Advanced Level Physics Teachers.
- Appendix 3- Focus Group Discussion Schedule for Advanced Level Physics Students.
- Appendix 4- A letter to the Ministry of Primary and Secondary Education requesting permission to conduct research at schools in Harare and Mashonaland Provinces in Zimbabwe.
- Appendix 5- A letter to the secondary school heads in Harare and Mashonaland central provinces requesting permission to conduct research.
- Appendix 6-An information-letter to the prospective participant.
- Appendix 7- Consent to participate in this study
- Appendix 8- A letter requesting parental consent for participation of minors in research project.
- Appendix 9 - A letter requesting assent from learners in secondary school to participate in research project.
- Appendix 10 - A letter requesting adult to participate in an interview.

In addition to these letters, the researcher also furnished the ethics committee with the following information:

- Background information of the study.

- Significance of the study.
- Methodology.
- Research design.
- Data collection instruments.
- Data collection procedures.
- Data storage mechanisms.

The researcher also signed a statement agreeing to comply with ethical principles as set out in the UNISA policy on research ethics. After meeting the requirements for ethical clearance, the researcher was finally issued with a Research Ethics Clearance Certificate (see appendix 12).

### **3.9 Chapter summary**

This chapter outlines the research methodology employed during the study where both qualitative and quantitative techniques were used in designing the instruments, in data collection and data analysis procedures. Creswell (2013), Gray (2011), Cohen, Manion and Morrison (2011) among many other authors refer to this current paradigm in research as the mixed methods approach. A case study research design was used where a total of twenty four participants from both teachers and ‘A’ level physics students were drawn from three high schools in Harare province. Basically three research tools for data collection, namely the structured observation schedule, interview schedule and focus group discussions were used. Discussions were also done on validity and reliability issues of both the instruments used and procedures for data collection where triangulation was the main guiding principle. Ethical issues guiding the research study were also observed where clearance from the UNISA ethics committee was sought before embarking on data collection.

## CHAPTER FOUR

### ASSESSMENT OF OBSERVED PRACTICAL WORK SKILLS AND SUBMITTED PRACTICAL WORK REPORTS

#### 4.1 Introduction

This chapter presents the findings, analyses and discussion on the mastery of practical work skills by ‘A’ –level physics students in the four broad areas of manipulation, observation, planning and designing of observed experiments. The chapter therefore presents and analyses quantitative data obtained from the assessment of students’ practical work skills using DAPS and IAPS methods. A total of six experiments were observed at three sampled schools. The eighteen students from the three schools performed two sets of experiments each that translated to a total of thirty six sets of marks. Pearson's correlation coefficient ( $r$ ) was calculated to determine the strength of the association between the mark obtained through direct assessment of practical work skills and the other mark obtained from the submitted practical work report for the same experiment. An analysis of the marked practical work reports of the six students observed at each of the three schools is also carried out in this chapter. Grades obtained by students from the marked practical work reports are compared with those obtained through observation. Similarities and differences in marks obtained by each student using direct and indirect assessment of practical work skills are also noted to establish any relationship from the assessment of the same practical activities using two different methods that is direct and indirect assessment.

Comments made on the student’s mastery of practical work skills using the direct and indirect methods of practical work skills are also compared. The essence of comparing the comments and grades obtained by students from direct observation of practical work skills with those from practical work reports is mainly to find out the relevance of the current method of assessing practical work and establish whether Zimsec adequately and effectively assess practical work skills in the broad areas of manipulation, observation, planning and designing using the current method of practical work assessment. This is done to establish how practical work assessment method influences the development of practical work skills of ‘A’ - level physics students as they might be a tendency of concentrating on presentation skills in order to pass practical work examination at the expense of developing other crucial skills which are currently not assessed directly. The discussion on the findings is done in section 4.9. This chapter addresses issues raised in research questions one and two:

*Research Question 1: How do ‘A’- level physics teachers assess practical work skills of students during the course of their programme?*

*Research question 2: How relevant are the assessment practices on students' practical skills development?*

The chapter is divided into the following sections:

- 4.1- Introduction
- 4.2- Observations made during practical work session and comments from the marked report for experiment 1.
- 4.3- Observations made during practical work session and comments from the marked report for experiment 2.
- 4.4- Observations made during practical work session and comments from the marked report for experiment 3.
- 4.5- Observations made during practical work session and comments from the marked report for experiment 4.
- 4.6 - Observations made during practical work session and comments from the marked report for experiment 5.
- 4.7- Observations made during practical work session and comments from the marked report for experiment 6.
- 4.8 - Rating of practical work skill mastery during observations against obtained mark from the submitted marked report: A Statistical Analysis.
- 4.9 - Comment on observational results: Relevance of the assessment practices on students' practical skills development.
- 4.10 - Chapter summary.

## **4.2 Observations made during practical work session and comments from the marked report for experiment 1**

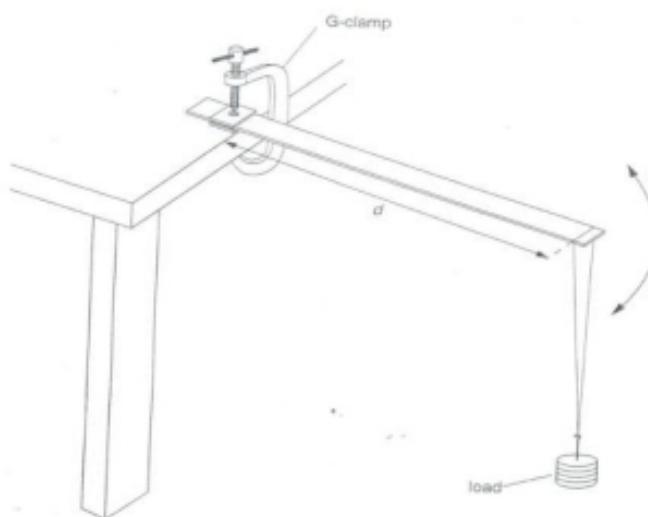
Experiment 1 as detailed in excerpt 4.1 was the first experiment students performed at school A under the observation of the researcher and the two research assistants.

Excerpt 4.1: An investigation of the oscillatory motion of a loaded metre rule

**Excerpt 4.1**

In this experiment you will be required to investigate the oscillatory motion of a loaded wooden metre rule (cantilever).

- (a) (i) Set up the cantilever as shown in Fig. 1.1. One end of the cantilever should be clamped firmly between the two blocks of wood to the bench using the G-clamp so that a length of 91.0 cm protrudes over the edge.



Suspend the load from the cantilever, using the loop of string, so that it is 1.0 cm from the free end. **The distance of the point of suspension of the load from the free end of the cantilever should remain fixed for the rest of the experiment.**

- (ii) Record the distance  $d$  from the edge of the bench to the point of suspension of the load.  
(iii) Slightly displace the end of the cantilever so that it oscillates in a vertical plane.

Make measurements in order to determine the period  $T$  of these oscillations.

- (iv) Adjust the position of the cantilever in the clamp to give a new value of  $d$ , and repeat steps (ii) and (iii) until you have a total of five sets of readings for  $d$  and  $T$ .

- (b) For this cantilever, the relation between  $T$  and  $d$  can be represented approximately by  $T = kd^n$

where  $k$  and  $n$  are constants.

- (i) Tabulate values of  $\log T$  and  $\log d$ .  
(ii) Plot these values on the graph grid on page 5.  
(iii) Draw the best straight line through your points.  
(c) By taking appropriate measurements from your graph, determine the values of the constants  $k$  and  $n$ .

The experiment entitled “An investigation of the oscillatory motion of a loaded metre rule” falls under the mechanics section of the ‘A’-level physics syllabus. Students’ mastery of practical work skills under the four broad areas of manipulation, observation, planning and designing were noted and necessary comments made. The comments were compared to those noted from the marked practical work report. This was done to find out on the areas of emphasis considering that two totally different methods of practical work skill assessment were used to assess the same students and the same practical work activity. The rationale of this approach was to establish whether the notion that the mastery of practical work skills under the four broad areas investigated could be inferred from the correctness of the results obtained by the candidate on the submitted practical work report. Table 4.1 gives a summary of the major comments noted using direct and indirect methods of practical work assessment.

Table 4.1 Comments on practical work skills assessment using the direct and in direct methods for experiment 1

<b>Skill</b>	<b>Observations and comments(Direct assessment of practical work skills)</b>	<b>Comments from the marked submitted practical work report.(in-direct assessment of practical work skills)</b>
<b>A</b>	<b>Manipulative Area</b>	Students generally slow and failed to set up apparatus perfectly 2/6 of the students asked for assistants from the teacher to set up the experiment
	A1 Manipulate effectively standard laboratory equipment	Students failed to score maximum marks on tabulation of results because of the following errors which include but not limited to: Missing or wrong units on values of log T and log d, Wrong column headings, Inconsistency of significant figures between raw values and calculated quantities, Out of range values.
	A2 Set up and use effectively the apparatus relevant to an experiment	The major problem noted was the inability by students to set up the cantilever so that it described an angle of $90^0$ to the bench. There was need to do this at the corner of the bench otherwise a protractor was needed to ensure that the cantilever was perpendicular to the bench. Only one student managed to effectively set up the apparatus
	A3 Work accurately, systematically and with reasonable speed	Poor reaction time where students were a bit either too fast or too slow in starting or stopping the stopwatch. Only two out of the six students observed were good at this skill It was necessary to make sure

		that the cantilever had stabilised before a student could take some readings. Only one student out of six managed to observe this important aspect.	Students failed to score maximum marks on graphical work because of the following reasons that include but not limited to: Could not draw the graph or complete the task after running out of time, Poor line of best fit, Interchanging the axis/wrong orientation of graph, Missing quantities or units on axis and poor choice of scale.
B	<b>Observational</b>		
	B1 Observe accurately.	Poor reaction time on the use of the stopwatch Parallax error as 3 out six of the students took readings for the oscillations while standing with a height difference of more than 50 cm from the level of the cantilever.	Poor line of best fit, Interchanging the axis/wrong orientation of graph, Missing quantities or units on axis and poor choice of scale.
	B2 Record observations accurately.	Four of the six students managed to record observations accurately. The other two did not take repeated readings and failed to include appropriate units on calculated values.	It is necessary to note that two of the students who struggled during the practical session produced good graphs and managed to score at least 4/5 marks allocated for graphical work. Only one student who was good during practical session managed to score 7/9 on table and an equally good mark of 4/5 on graphical work. Two of the students who were very good during the practical session produced pathetic graphs and justifiably scored only 1/5 marks allocated. The remaining one student who struggled during practical session also produced a poor table and graph and failed to score more than half of the marks allocated.
C	<b>Planning/Designing</b>		
	C1 Plan an experimental procedure, applying standard laboratory techniques	Because of the noted problems above, students' planning was generally poor in terms of experimental set up, taking of readings and taking precautions to avoid random and systematic errors.	Students failed to score maximum marks on analysis because of the following reasons that include but not limited to: Failure of linearization of the relationship $T=kd^n$ by taking logarithms $\log T=n \log d + \log k$
	C2 Modify established techniques to suit novel experimental situations	Students lacked innovation	Failure to realise that $n$ is the gradient and $\log K$ the intercept  Failure to get results of $n$ and $k$ within range that is $n=0.9-1.2$ and $k=.0.8-1.0$ according to the teacher's marking scheme.  Two of the students who produced good tables and graphs failed to score a single mark on data analysis .One student who struggled during

		practical session scored ¾ marks allocated on analysis. One student who was very good during practical session sadly failed to get enough time to do analysis and resultantly scored 1/4 in this section. The remaining two students who were just average during practical session managed to get values of k and n which were within range of the expected.
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Two completely different stories can be told from the observation scores made during practical work session for experiment one and comments as well as the marks obtained by students from the marked practical work report. Observations made during practical work sessions for experiment one generally reflect that students struggled to master basic skills of manipulation, observation and planning. The teacher had to assist two students in setting up the experiment. Sixty percent of the students observed failed to realise the importance of taking precautionary measures that could ensure the production of accurate results. This could have been done by the students through ensuring that the cantilever was perpendicular to the bench by either using a protractor or mounting it at the corner of the table in experiment 1. Two students failed to realise the importance of taking repeated readings to reduce random errors.

Poor reaction time was also another problem noted on operation of the stopwatch. Two students had a problem of stopping the stop watch before a complete oscillation while one was slow such that this was done after a complete oscillation. One student could not actually define an oscillation judging from the way he was operating the stop watch. Students' planning was generally poor in terms of experimental set up, taking of readings and precautions to avoid random and systematic errors.

Considering all the four skills of manipulation, observation, planning and designing from which the final mark on direct assessment of practical work skills only three students out of the six under observation managed to get a pass mark of 50% or above. The scoring was done using a rating scale (0-10) used by the researcher to assess students on the mastery of practical work skills as outlined in appendix 1.

It is interesting to note that the story was different with regards to students' performance from the submitted marked reports through indirect assessment of practical work skills on the same experiment outlined in excerpt 4.1. Although Zimsec claims that the mastery of practical work skills by students during practical work session can be inferred from the correctness of the values obtained by the student on the submitted practical work report, the observations on experiment one showed otherwise.

The skills exhibited by the students during practical work session appeared not to be the basis of the grade obtained by the student on the marked practical work report.

Students observed produced good reports with four out of six passing and the two failing mainly because of failure to complete the write up after running out of time. Of interest to note is that two students who failed during direct observation of practical work skills passed from the submitted practical work report while list one student who passed during direct assessment of practical work skills failed to pass from the practical work report. The major reason for failure by the student on the practical report was mainly because of failure to complete the write up losing more than half of the marks allocated for graphical work and all the marks on analysis. This shows a mismatch between the skills that are actually assessed on the practical work report as compared to those exhibited by the students during practical work sessions.

Higher marks were generally scored by students on presentation of results where five out of the six students observed were aware of the importance of including SI units on measured quantities as well as values of  $\log T$  and  $\log d$ , inclusion of appropriate column headings, taking the required number of readings as wells consistency of significant figures between raw and calculated values.

The performance on graph work was not as good as compared to tabulation of results. The major problem noted on graph work was mainly missing quantities or units on axes, poor choice of scale and in only one case interchanging the axes resulting in wrong orientation of the graph. Only one student who was good during practical session scored a high mark of 5/5 on graphical work.

The worst performance considering the sections where students were scored was on result analysis where sadly two students did not score a single mark because of limited time to complete the write up. One student had wrong calculations of values of  $k$  and  $n$ . Only three out of the six observed students managed to score something.

In summary students performed better from the marked practical work report as compared to the scores obtained during direct assessment of practical work skills for experiment one. This is so because only three students, whose practical work skills were assessed in the four areas of manipulation, observation, planning and designed passed as compared to four who passed from practical work reports. It is important to note that those students who passed during direct assessment of practical work skills were not necessarily the same students who passed from the marked practical work reports and vice versa. Of the six observed students only two passed using both direct and indirect assessment of practical work skills. It appears students may pass practical work without exhibiting key practical skills during practical work session but because of good presentation skills.

The issue of limited time to complete the practical report write up contributed significantly to poor performance. The major question which will be tackled under the section on analysis and discussion remain that: Which practical work skills are actually assessed from the practical work examination of the ‘A’ level physics syllabus 9188 offered by Zimsec?

### **4.3 Observations made during practical work session and comments from the marked submitted report for experiment 2**

Experiment two as detailed in excerpt 4.2 was the second experiment students performed at school A under the observation of the researcher and the two research assistants. Experiment two falls under the electricity section of the ‘A’ level physics syllabus.

Excerpt 4.2: The variation of potential difference with resistance

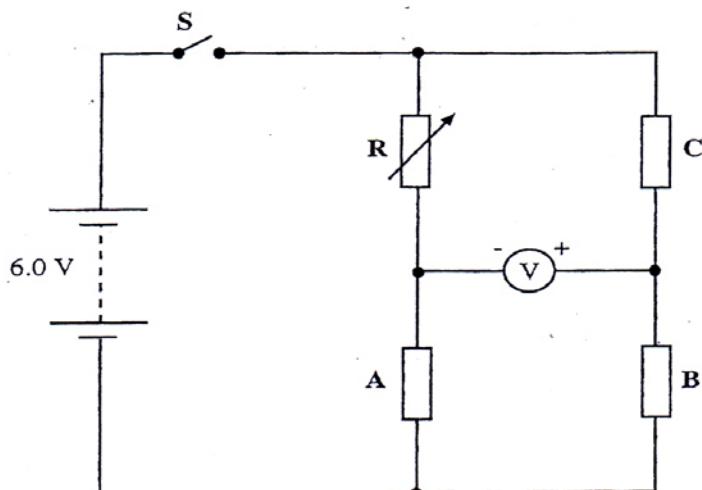
#### **Excerpt 4.2**

**It is recommended that you spend about 60 minutes on this question.**

In this experiment you will investigate the variation of potential difference with resistance.

A, B and C are resistors. The variable resistor, R, is formed by connecting the 100  $\Omega$  resistors provided. One or more of these can be used to obtain different values of R.

Set up the circuit as shown in Fig. 2.1.



**Fig. 2.1**

- (a) (i) Using one value of R, close the switch, record R, and record V.
- (ii) Change the value of R and repeat a(i) for five further sets of values of R and V.

**N.B.** For series resistors  $R = R_1 + R_2 + \dots$

$$\text{For parallel resistors } \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$$

- (iii) Include in your table of results, values of  $\frac{100}{100 + R}$ .

(iii) Include in your table of results, values of  $\frac{100}{100 + R}$

(iii) Use your graph of V (y-axis) against  $\frac{100}{100 + R}$

b (i) The voltmeter reading, V and R are related by the equation

$$V = K - \frac{100M}{100+R} \quad \text{Where } K \text{ and } M \text{ are constants}$$

(ii) Plot graph of V(y-axis) against  $\frac{100}{100 + R}$

(iii) Use your graph to determine values of K and M

(iv) Determine a value of R for which V = 0

(c) In this experiment, state any **two** advantages of a digital voltmeter over an analogue one.

Students' mastery of practical work skills under the four broad areas of manipulation, observation, planning and designing were noted and necessary comments made. For each of the four skills students' mastery of the skills was rated on a scale of 0-10. The overall grade obtained by the student from the observations made was expressed as a percentage. The comments were compared to those noted from the marked practical work report. This was done to find out on the areas of emphasis considering that two totally different methods of practical work skill assessment were used to assess the same students and the same practical work activity. The rationale of this approach was to establish whether the notion that the mastery of practical work skills under the four broad areas investigated could be inferred from the correctness of the results obtained by the candidate from the submitted practical work report as advocated by Zimsec. Table 4.2 gives a summary of the major comments noted using direct and indirect methods of practical work assessment for experiment 2.

Table 4.2 Comments on practical work skills assessment using the direct and in direct methods for experiment 2

<b>Skill</b>	<b>Observations and comments(Direct assessment of practical work skills)</b>	<b>Comments from the marked submitted practical work report.(in-direct assessment of practical work skills)</b>
<b>A</b>	<b>Manipulative Area</b> A1 Manipulate effectively standard laboratory equipment	<p>Poor manipulation of equipment where half of the six students under observation were assisted in setting up the laboratory equipment.</p> <p>It was evident from their struggles that the six students under observation lacked basic skill of manipulation.</p> <p>One candidate failed to get two of the combinations of resistors needed and ended up with only four readings instead of six.</p>
	A2 Set up and use effectively the apparatus relevant to an experiment	<p>3/6 of the students failed to connect the circuit and had to ask for assistance from the teacher. One student interchanged terminals and was getting negative values before the teacher intervened and rectified the problem.</p> <p>2/6 of the candidates were taking readings before the digital voltmeter had stabilised. This was caused mainly by loose connections which needed to be tightened.</p> <p>One student failed to get results and later on the physics teacher realised that both the power supply and the voltmeter were not functioning well and had to wait for others to finish before embarking on the experiment.</p> <p>Three of the six students under observation had good connections and obtained results within expected range.</p>

		<p>One student had to be assisted for a combination where two resistors were connected in parallel and one in series.</p>	not limited to:
	A3 Work accurately, systematically and with reasonable speed	<p>Students were generally slow in their operation and lacked confidence in what they were doing.</p> <p>Instead of using the circuit board provided, two students under observation decided to join the resistors resulting in loose connections and unstable readings. Resultantly the values obtained by these students were out of range of the expected.</p> <p>Trial and error method by half of the observed candidates</p> <p>One student under observation failed to connect three resistors in parallel in the circuit.</p>	<p>Missing graph title, Failure to label axis, Scattered points which did not reflect any pattern, Failure to take appropriate readings to calculate gradient and wrong or poor choice of scale.</p> <p>Two of the candidates who struggled much during practical session and who failed to score more than half of the marks under the four broad areas of manipulation, observation, planning and designing managed ironically to score high marks under table of results as well as graphical work. The other two students who were good during practical session however managed to score very high marks of at least 7/10 on table of results and 5/6 on graphical calculations. The remaining two students who found the going tough during practical sessions hardly managed to get more than half of the marks allocated for tabulation and graphical work showing a positive relationship between scores obtained by students using different methods of practical skills assessment.</p>
B	<b>Observational</b>		
	B1 Observe accurately.	Despite the fact that the circuit diagram was provided two of the observed candidates could not correctly connect the circuit.	
	B2 Record observations accurately.	<p>4/5 of the candidates managed to record observations correctly</p> <p>Two of the candidates did not include correct units and failed to take appropriate number of significant figures on calculated quantities.</p>	<p>From the observations made on the marked practical work reports, the worst performance by students was on analysis of results where students failed to score maximum marks because of some of the following reasons that include but not limited to:</p>
C	<b>Planning/Designing</b>		<p>Inadequate time to complete the practical work report write up.</p> <p>Failure to take correct values of the gradient and the intercept and subsequently failing to determine values of K and M</p>
	C1 Plan an experimental procedure, applying standard laboratory	Poor planning by half of the candidates under observation with a lot of trial and error. Without the assistance of the	Failure to state any two advantages of a digital voltmeter over an analogue one.

	techniques	teacher these students could not have recorded a single value. The other three candidates had a clear plan for their activities.	Only one of the six students observed managed to score very high marks in the three areas of tabulation of results, graphical work and data analysis as well as being very good during practical session where the student managed to score more than 75% of the marks allocated. The other two students who were good during practical session either failed to complete the write up or got values of K and M which were out of range of the expected. Two students who struggled during practical session managed to squeeze pass marks of above 60% because of their good presentation skills. One student who struggled during practical session and failed to record the six readings needed to plot the graph failed to get an overall pass mark .Students generally scored higher marks from practical work reports than from direct assessment of practical work skills in this experiment on investigating the variation of potential difference with resistance.
	C2Modify established techniques to suit novel experimental situations	General lack of innovation	

Only two out of the six observed students managed to pass from direct assessment of practical work skills in the four broad areas of manipulation, observation, planning and designing in experiment 2 outlined in excerpt 4.2. The major problem noted from the observations during practical work session was that students struggled to correctly and effectively set up the circuit. Three students had to be assisted in setting up the circuit as they completely failed to interpret the circuit diagram shown in excerpt 4.2. The other three who finally managed to set up the circuit succeeded through trial and error where in one case the student interchanged the terminals resulting in negative values. A loose connection was another problem which resulted in instability of voltmeter readings. This resulted in students taking inaccurate values of  $v$  because of continuous changes.

One student failed to get two of the six combinations of resistors required resulting in four sets of readings. It means the student lost some marks on both table of results and graphical work. Instead of using the circuit board provided, two students decided to form the combinations by joining resistors. This affected the values of  $v$  as some of the values obtained were out of range. One student connected the voltmeter on a wrong scale range of the multimeter and as a result values of  $v$  were not changing

for different values of **R**. The physics teacher noted this and rectified the problem accordingly. Because of these noted problems, observed students lost many marks and four of the six failed to score pass marks.

Students who had connected their circuits accurately and effectively did not face many problems in accurate recording of observations. Four of the six students were using digital voltmeters and as such did not face any problem on correct reading of instrument. The two students who used analogue voltmeters took note of the importance of reducing parallax error.

Out of the four skills under observation and assessment, students did not perform well in areas of planning and manipulation where four out of six observed students obtained marks below 50% in these two categories. All the six students however managed to score above 50% on observational skills. The overall assessment was that students lacked basic skills of manipulation, observation, planning and designing. Three of the observed students were generally slow taking more than half of the time allocated carrying out the experiment leaving very limited time to do the write up. This was mainly due to lack of confidence and innovation.

The situation was quite different on indirect assessment of practical work skills from the practical work report. Four of the six students who participated in the study managed to pass from indirect assessment of their practical work skills as opposed to two using the direct method. The performance of the students was far much better with three of the six students getting marks above 70%. Ironically, one of the two students who failed from indirect assessment of practical work skills (IAPS) through the assessment of practical work reports was one of the only two who passed through direct assessment of practical work skills.

The students who failed from the assessment of practical work reports was as a result of mainly failure to complete the write up and failure to analyse the results to determine values of **K** and **M**. Three out of the four students who passed through assessment of practical work reports had failed during direct assessment of practical work skills (DAPS). One student who had failed during direct assessment of practical work skills amazingly got a distinction from the assessment of the practical work report. Only one student passed both through direct and indirect assessment of practical work skills.

The major problem faced by students considering their practical work reports was mainly on data analysis. Students scored high marks on data presentation section. Three of the six students obtained marks above 70% in this section as they were aware of the need to take six readings, label column headings with appropriate quantity and units among other requirements that guaranteed them maximum marks.

The performance on graphical work was equally impressive. Four of the six students managed to score above 60% with two students who were struggling during practical session scoring below half. The students did not do well on data analysis. Only two students managed to score above 60% in this section with one getting 50% and the other three scoring below half.

Judging from students' overall performance on practical work reports assessment, it appears students were quite aware of the expectations on tabulation of results, graphical work and data analysis. The results from experiment two show that students had mastered their presentation skills judging from the quality of their practical work reports despite struggling to master the four skills of manipulation, observation, planning and designing during practical sessions. For the two experiments carried out by students at school **A**, the students performed better using indirect assessment of practical work skills through practical work reports than direct assessment of practical work skills during practical sessions.

#### **4.4 Observations made during practical work session and comments from the marked submitted report for experiment 3**

Experiment 3 as detailed in excerpt 4.3 was the first experiment students performed at school **B** under the observation of the researcher and the two research assistants. Experiment three falls under the mechanics section of the 'A' level physics syllabus.

Excerpt 4.3: Investigating the rate of rise of water in a graduated measuring cylinder

### Excerpt 4.3

**It is recommended that you spend about 60 minutes on this question.**

In this experiment you will investigate the rate of rise of water in a graduated measuring cylinder. Set up the apparatus shown in Fig 1.1 ensuring the burette is vertical.

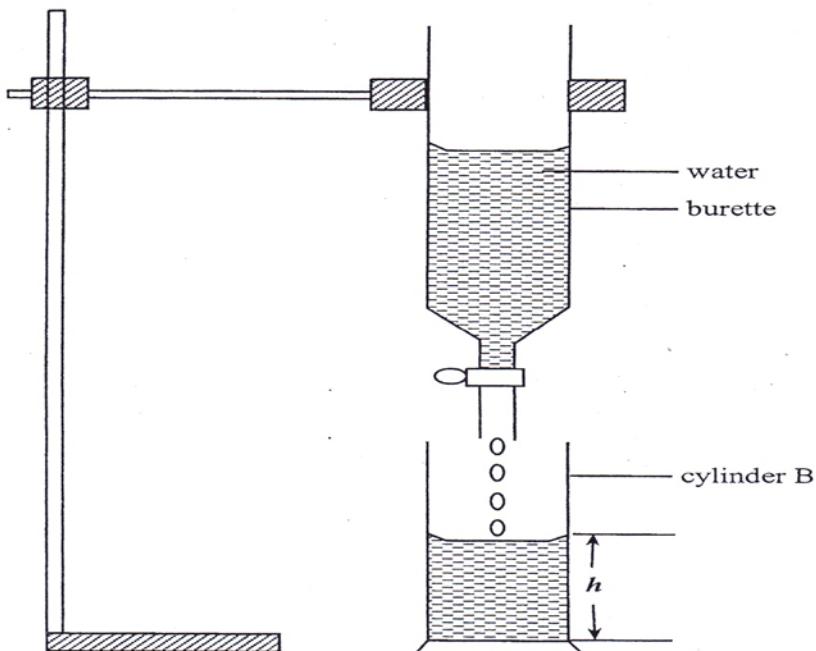


Fig. 1.1

- (a)
  - (i) Fill up the burette with water and open its tap briefly to allow some water to completely fill the lower part of the burette. Make further adjustments to ensure the burette level is at the  $0 \text{ cm}^3$  mark.
  - (ii) Start the stopwatch as you open the burette tap **completely**.
  - (iii) Measure and record the time,  $t$ , it takes for the water to rise to height,  $h$ , in cylinder B (*which must initially be empty*).
  - (iv) repeat a(iii) for seven further sets of values of  $t$  and  $h$ .  
[ $2.0 \leq h \leq 13.0 \text{ cm}$ ].
- (b) (i) Plot a graph of  $h$  against  $t$ .  
(ii) Determine the gradients of the tangents at the points where  $t = \frac{T}{5}$   
and  $t = \frac{T}{2}$  where  $T$  is the greatest value of  $t$  recorded in the table.
- (c) (i) Theory suggests that the rate of rise is related to  $t$  by the equation  $\frac{dh}{dt} = \frac{53k}{c} e^{-kt}$  where  $k$  and  $c$  are constants.  
(ii) Use this equation and the two values of gradients determined in (b) (ii) to get values of  $k$  and  $c$

Like in the previous two experiments ,the purpose of direct assessment of students' practical work skills in the four broad areas of manipulation, observation, planning and designing was to compare the results with those obtained through indirect assessment of practical work skills based on the submitted practical work report. The rationale is to test the claim by Zimsec that the correctness of the results or values obtained by a candidate from the submitted practical work report is a direct reflection of the mastery of practical work skills during practical work session. Table 4.3 gives a summary of the major comments noted using both direct and indirect methods of practical work assessment.

Table 4.3 Comments on practical work skills assessment using the direct and in direct methods for experiment 3

<b>Skill</b>	<b>Observations and comments(Direct assessment of practical work skills)</b>	<b>Comments from the marked submitted practical work report.(in-direct assessment of practical work skills)</b>
<b>A</b>	<b>Manipulative Area</b>	
	A1 Manipulate effectively standard laboratory equipment	Three of the six students failed to perfectly set up the apparatus as their burettes were not vertical. Poor reaction time observed on four students.
	A2 Set up and use effectively the apparatus relevant to an experiment	The major challenge noted was the failure by three of the six observed students to set up the burette so that it was vertical .A set square could have been used to ensure this.  Poor reaction times on opening and closing the burette tap at the same time starting or stopping the stop watch. This was observed on four of the six students observed.  Parallax error on taking the value <b>h</b> as it was necessary for the eye to be at the same level with the meniscus of the liquid in the cylinder.
	A3 Work accurately, systematically and with reasonable speed	Reaction time was the major challenge observed on four students. Five students were generally fast with only one student who had to rush towards the end but failed to complete writing the practical work report. Three of the students observed failed to

		take repeated readings to improve on the accuracy of the value of <b>h</b> .	was that only two of the six students observed had a good presentation of results scoring at least six of the eight marks allocated for data presentation.
B	<b>Observational</b>		
	B1 Observe accurately.	Three students made good observations while the other three could not avoid the parallax error.  Need for repeated readings to improve accuracy. Three students did not observe this.	Observed students failed to score a maximum of 5 marks allocated for graphical work because of the following reasons that include but not limited to: Wrong orientation of graph, Drawing a straight line graph instead of a curve, Failure to label axes, Inaccurate tangent, Missing graph title.
	B2 Record observations accurately.	Four observed students recorded observations accurately, two did not take note of SI units	
C	B3 Read instruments correctly	Poor reaction time  Parallax error	One student failed to indicate on the graph values of <b>t</b> for <b>t=T/5</b> and <b>t=T/2</b> and as a result lost some marks. Two students failed to draw smooth curves and as a result it was difficult to take a tangent at a given point as it was difficult to clearly locate this point. One student lost marks for wrong orientation of graph and another for failing to correctly label the axes. Two students drew straight lines instead of curves and as a result lost more than half of the marks allocated for graphical work. Only one student managed to draw a good graph and scored 5/5 marks.
	C1 Plan an experimental procedure, applying standard laboratory techniques	Only three of the six students observed managed to effectively plan the experimental procedure, applying standard laboratory techniques.	Observed students failed to score a maximum of 6 marks allocated for analysis of results because of the following reasons: Failure to do the calculations after running out of time, Getting values of <b>K</b> and <b>C</b> which were out of range, Wrong calculations for intercept or gradient.
C2 Modify established techniques to suit novel experimental situations			This is the section where observed students scored the least number of marks with three students scoring 0/6 because of wrong calculations or failing to attempt after running out

		of time. Generally half the marked reports observed showed that students lacked basic knowledge of calculus to deal with exponential functions. Only one student out the six managed to get values of K and C which were within range and scored 5/6 marks with the remaining two students scoring 2/6 and 3/6.
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Four of the six observed students scored pass marks during direct assessment of practical work skills (DAPS) at school **B** in experiment 3. This was the same number of students who also passed using indirect assessment of practical work skills (IAPS) from the practical work reports. Ironically, two students who passed during DAPS failed the assessment through IAPS and the other two who passed from the practical reports had failed during DAPS. It follows that, only two students passed using the two different methods of practical work skills assessment. Students who were subjects of this research scored higher on IAPS than on DAPS. There was no case where students failed both during DAPS and IAPS.

Observed students struggled very much in mastering of manipulative skills. This was evidenced by failure by half of the observed students to effectively set up the burettes. There was general lack of innovation in ensuring that the burette was vertical as per experimental instruction. This could have been done through the use of a set square, protractor or measuring equal distance from the clamp stand to the burette on the lower and upper end of the burette to ensure that it was vertical. The other problem noted on three of the six students who participated in the study was poor reaction time. This was observed during opening and closure of the burette tap where concurrently the student was also expected to start and stop the stopwatch respectively. This in a way affected the quality and precision on the values of **h** and **t**. The other noted problem during DAPS was that of parallax error in taking the values of **h**. It was important for the eye to be at the same observation level with the meniscus of the measuring cylinder to reduce parallax error when taking values of **h**. It was also important to take repeated readings to reduce random error. Three of the observed students failed to take note of this important aspect to improve the quality of their results.

It was interesting to note that half of the students tried to reduce errors through effective manipulation of equipment, good observations and effective planning of experimental procedure. Unfortunately only two these students managed to pass both through DAPS and IAPS. The other half of the observed students in this study lacked innovation to suit novel experimental situations like ensuring that the burette was vertical or having uniform intervals for values of **h**. A common problem on the

six students who participated was that of slowness in doing the experiment, leaving them with limited time to do the write up. The situation was remarkably different with regards to IAPS through practical work reports. A total of four students out of six passed, scoring at least 70% through IAPS from the submitted practical work report.

Tabulation of results was quite problematic to four of the six students observed. Two students failed to record the seven sets of readings required and subsequently lost marks allocated for that. The other areas where students easily lost marks on data presentation were failure to use SI units and symbols and failure to include a title on the table of results. Only two students produced good tables of results and scored 90% of the marks allocated.

The worst performance on the three areas where students were assessed using IAPS was on graphical work. Students were expected to draw a curve but two of them drew a straight line graphs and resultantly lost marks on both graphical work and result analysis. Of the four students who managed to drew curves, two of them had thick lines making it difficult to determine the gradients of the tangents at points  $t=T/5$  and  $t=T/2$ . One student lost some marks for wrong orientation of graph and the other failed to complete drawing the graph because of limited time. Two of the six students who participated in the study managed to score above half on graphical work.

The section on analysis of results was not well done. Three students scored 0/6 because of wrong calculations. This was caused mainly because of lack of basic knowledge of calculus to do calculations involving exponential functions. Only one student out of the six reports managed to get values of  $k$  and  $c$  which were within range of the expected values. The other source of mark loss was limited time to do the calculations where two students did not attempt this section. One of the two students sadly was very good on DAPS.

The overall picture shown on IAPS for experiment three was that, the students lacked enough time to complete the write up and that they also lacked basic knowledge of calculus to deal with exponential functions. It was evident from the results of the students through IAPS that one can easily pass after mastering presentation skills despite lacking basic skills of manipulation, observation, planning and designing which resulted in them scoring badly on DAPS.

#### **4.5 Observations made during practical work session and comments from the marked submitted report for experiment 4**

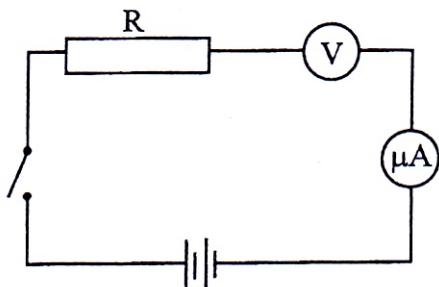
Experiment 4 as detailed in excerpt 4.4 was the second experiment students performed at school **B** under the observation of the researcher and the two research assistants. This experiment falls under the Electricity section of the ‘A’ level physics syllabus.

Excerpt 4.4: Determining the resistance  $R_v$  of a voltmeter

#### Excerpt 4.4

**It is recommended that you spend about 60 minutes on this question.**

In this experiment you will determine the resistance  $R_v$  of a voltmeter. Set up the circuit as shown in **Fig. 2.1**.  $R$  is a resistor obtained by either using one or more of the three resistors given. Each resistor has a resistance of  $47\text{ k}\Omega$ .



**Fig. 2.1**

- (a) (i) Close the switch and record  $I$ , the ammeter reading. Record the corresponding value of  $R$ .
- (ii) By changing the value of  $R$ , obtain six more sets of measurements of  $\frac{1}{I}$  and  $R$ . Include the values of  $\frac{1}{I}$  in your table of results.
- (b) It is known that  $R$  and  $I$  are related by the equation.

$$R = \frac{A}{I} + R_v \text{ where } A \text{ is a constant.}$$

- (i) Draw a suitable graph to enable you to find  $A$  and  $R_v$ .
- (ii) Find the values of  $A$  and  $R_v$ .
- (c) State **one** precaution in this experiment.

Table 4.4 gives a summary of the major comments noted using both direct and indirect methods of practical work assessment.

Table 4.4 Comments on practical work skills assessment using the direct and in direct methods for experiment 4

<b>Skill</b>	<b>Observations and comments(Direct assessment of practical work skills)</b>	<b>Comments from the marked submitted practical work report.(in-direct assessment of practical work skills)</b>
<b>A</b>	<b>Manipulative Area</b>	Poor manipulative skills observed on three of the six students. Trial and error on circuit connection by two of the observed students.
	A1 Manipulate effectively standard laboratory equipment	Three of the six students observed had to be assisted in setting up the circuit. Despite having a correct set up one student failed to record accurate readings of <b>I</b> because of loose connections that resulted in unstable ammeter reading. Only two students had perfect connections that were also evidenced with the good values of <b>R</b> and <b>I</b> recorded. Two students faced difficulties in connecting a circuit which required a combination of resistors in series and parallel.
	A2 Set up and use effectively the apparatus relevant to an experiment	Accuracy affected by wrong experimental set up observed on two students.  Loose connections affected readings of one student. Generally two of the students were slow. Only one student worked accurately, systematically and with reasonable speed.
<b>B</b>	<b>Observational</b>	
	B1 Observe accurately.	Five of the six students managed to do correct observations.
	B2 Record observations accurately.	Five of the students had accurate observations. One student was affected by poor set up of the circuit.

	B3Read instruments correctly	Parallax error on instrument reading observed on two students using analogue ammeters.	Missing graph title, Poor choice of scale, Wrong orientation of graph.
C	<b>Planning/Designing</b>		One observed student drew a graph that was wrongly oriented and as a result lost marks for both graphical work and analysis. One student failed to draw a graph because of lack of time to do so. One student did not label the axes and the title was missing. The remaining three students managed to draw fairly good graphs scoring at least 4/6 marks allocated for this section.
	C1 Plan an experimental procedure, applying standard laboratory techniques		More than half of the students had to be assisted in planning an experimental procedure as they failed to apply standard laboratory techniques in circuit designing.
	C2Modify established techniques to suit novel experimental situations		<p>This was a challenge to half of the observed students as they bypassed a switch and failed to appreciate the use of the available circuit board to connect resistors in parallel or series than using extensions to join these resistors which in most cases resulted in loose connections.</p> <p>Observed students failed to score a maximum of 5 marks allocated for analysis of results because of the following reasons which include but not limited to:</p> <ul style="list-style-type: none"> <li>Running out of time to do analysis,</li> <li>Failure to state the precaution,</li> <li>Out of range values of <math>A</math> and <math>R_v</math>,</li> <li>Wrong calculations of values of <math>A</math> and <math>R_v</math>.</li> </ul> <p>Two students did not score anything in this section because of lack of time. One student had wrong calculations for values of <math>A</math> and <math>R_v</math> caused by taking inappropriate values of the intercept and gradient. One student had out of range values of <math>A</math> and <math>R_v</math>. Only two students managed to score above half in this section both getting 3/5 of the marks. Generally students observed produced very poor reports as compared to the skills that they exhibited during practical work session.</p>

Experiment four had results which have a different trend to the previously observed ones. Four of the six students passed during DAPS and only two through IAPS. The quality of the results were better on DAPS as compared to IAPS. This was mainly because of the fact that students spent almost three quarters of their time doing the experiment leaving them with very limited time to do the write up. This is a sad scenario where students were able to exhibit basic skills in manipulation, observation,

planning and designing but failed because of poor management of time to do the write up which was the basis of IAPS. This result shows that the methods employed to assess practical work do not give a true reflection of the skills that are possessed by the students. It only shows the possibilities of practical work skills that may be possessed by students than providing a real picture of their abilities. The following paragraphs give a detailed account of how the six students were assessed using IAPS and DAPS for experiment four.

Observed students performed fairly well during DAPS where they exhibited basic skills of manipulation, observation, planning and designing. Four of the six students managed to pass during DAPS with the highest score of 73%. Observed students however had their fair share of problems in trying to master the skills in the four areas of manipulation, observation, planning and designing.

Half of the students struggled to master the manipulative skills where cases of trial and error were observed on circuit connection. The other three observed students had to be assisted to set up the circuit. Loose connections affected the quality of the values of **I** where students recorded readings before the ammeter had stabilised. This affected the accuracy of the readings recorded by two of the observed students. Five out of six students showed a good mastery of observational skills. Despite the noted problems, the six students who were assessed through DAPS had basic skills of manipulation, observation, planning and designing. The challenge however was on time management where the students spent too much time in doing the experiment leaving them with limited time to do the write up.

The overall performance by the students on IAPS through the practical work reports was poor because students did not get enough to write the practical work report. As a result only two of the six students who participated in the study at school **B** passed from the assessment of their practical work reports. There were however other challenges that were encountered by the students in the three areas of result presentation, graphical work and analysis that affected students' performance.

The major problem noted on result tabulation was that of wrong calculations of values of **1/I** because of the failure by the students to use SI units for current. This affected half of the students judging from their table of results. Two students had result of **I** which were out of range and lost some marks as a result. The overall performance of students on result presentation was good with two students getting 90% of the marks allocated.

The performance on graph work was not as good comparing with that on results presentation. Two students failed to get 50% of the marks allocated on graphical work because of failure to label axes, poor choice of scale and wrong orientation of graph. One student failed to draw the graph after running out of time to do so. Three students were quite good in this section. These students managed to score at least four out of the six marks allocated on graph work.

Like in all cases observed up to experiment four the worst performance by students was on results analysis. Two of the six students who participated in the study failed to score a single mark because of limited time to do the analysis. One student had wrong calculations. Only two students managed to score more than half of the marks allocated on analysis of results.

Generally, students observed produced very poor reports as compared to the skills that they exhibited during practical work session. Again, this result shows a different picture on the mastery of practical work skills by students compared to those which are assessed. Students failed on the assessment of practical work reports not because they did not have basic practical work skills of manipulation, observation, planning or designing, but they failed to put them in writing in order to score marks through IAPS. The main reason for such a sad scenario in addition to poor result analysis was limited time to do the write up where students had to rush through the write up in the process making several mistakes. The score that the student get is influenced by the method that is used to assess the practical work activity more than the skills that the students have from the reflections of practical work assessment through both DAPS and IAPS as evidenced by the performance of the six students who participated in experiment four.

#### **4.6 Observations made during practical work session and comments from the marked submitted report for experiment 5**

Experiment 5 as detailed in excerpt 4.5 was the first experiment students performed at school C under the observation of the researcher and the two research assistants. This experiment falls under the mechanics section of the ‘A’ level physics syllabus. The structure of this experiment is slightly different from the four previously observed but again it was possible to assess the students in the four areas of manipulation, observation, planning and designing as the students were carrying out the experiment. Students were not expected to draw a graph on in the practical report but mainly presentation and analysis of results as well as answering questions that required some design skills.

Marked reports from the submitted practical work reports were also scrutinised to see how students responded to different questions and how they were scored. The idea was to compare the performance of the students from the marked practical work report to how they fared during DAPS in the four areas of manipulation, observation, planning and designing during the practical work session. The assumption is that if both methods of practical work assessment are valid and reliable then they are expected to produce the same results. The situation up to this point considering results from the four observed situations however has shown that students perform generally better when the assessment is done indirectly through practical work reports than direct assessment of practical work skills.

Excerpt 4.5: Investigating how the stopping distance of a model vehicle depends on its mass

### Excerpt 4.5

You may not need to use all of the materials provided.

In this experiment, you will investigate how the stopping distance of a model vehicle depends on its mass.

(a)(i) Record the mass  $m$  of the model. This information is given on the card.

$$m = \dots \text{g}$$

(ii) Measure and record the length  $L$  of the model, as shown in Fig 2.1.

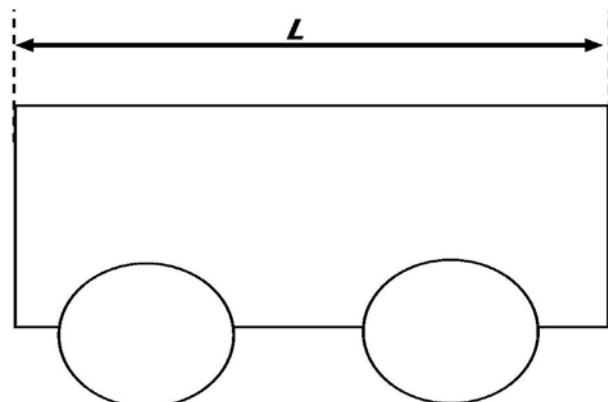


Fig 2.1

$$L = \dots [1]$$

(b)(i) Support the board as shown in Fig 2.2.

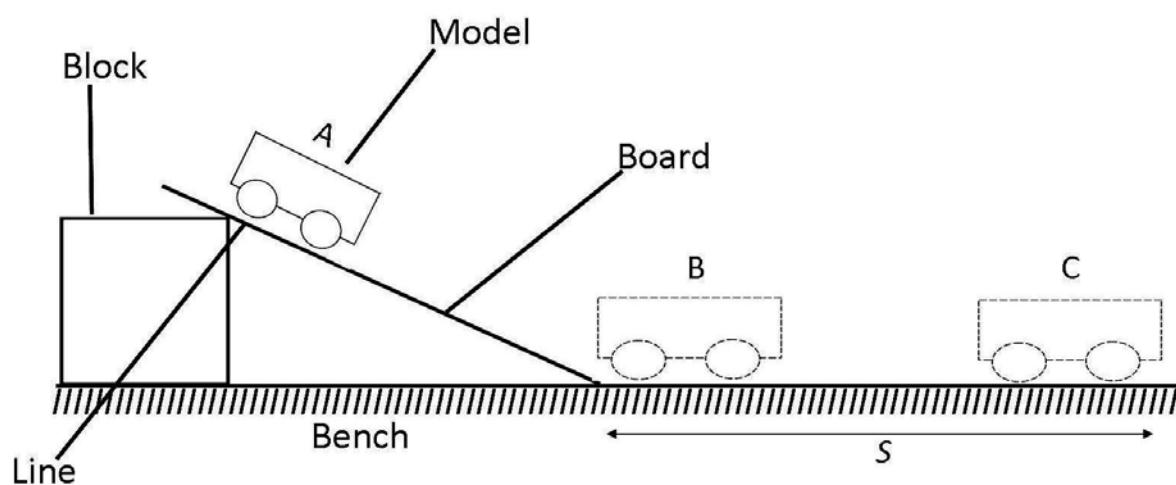


Fig 2.2

Place the **back** wheels of the model on the line. This is position **A**.

Release the model. It travels a distance of 40cm down the board until all the wheels are on the bench. This is position **B**.

The model moves a distance along the bench before stopping. This is position **C**.

Distance  $s$  is measured from the end of the board to the front of the model as shown in Fig 2.2.

(ii) Justify the number of significant figures that you have given for your value of  $v$

(e)(i) Fix the 100g mass on top of the model using the Blue-Tack.

(ii) Calculate and record the total mass  $M$  of the model and the 100g mass.

$$M = \dots \text{g}$$

(iii) Repeat (c) and (d)(i).

$$t = \dots$$

$$s = \dots$$

$$x = \dots$$

$$v = \dots$$

(f) It is suggested that  $v$  remains when  $M$  is changed.

Explain whether your results support the suggested relationship.

(ii) Repeat (b) (i) until  $s$  is approximately 60cm.

It may be necessary to adjust the slope of the board before releasing the model.

**Do not adjust the slope of the board throughout the remainder of the experiment.**

Measure and record the distance  $s$

$$s = \dots [2]$$

(iii) Estimate the percentage uncertainty in your value of  $s$ .

Percentage uncertainty = ..... [1]

(iv) Use your values from (a)(ii) and (b)(ii) to determine the distance  $x$  moved by the model between B and C, where

$$x = s - L$$

$$x = \dots [1]$$

(c) Replace the model at A.

Release the model.

Measure and record the time  $t$  taken to move from B to C and the distance  $s$ .

Calculate  $x$ .

$$t = \dots$$

$$s = \dots$$

$$x = \dots [1]$$

(d)(i) Calculate the average speed  $v$  of the model between B and C using the relationship

$$V = \frac{x}{t}$$

$$v = \dots [1]$$

(g)(i) Describe four sources of uncertainty or limitations of the procedure for this experiment.

(ii) Describe four improvements that could be made to this experiment. You may suggest the use of other apparatus or different procedures.

Table 4.5 gives a summary of the major comments noted using both direct and indirect methods of practical work assessment.

Table 4.5 Comments on practical work skills assessment using the direct and in direct methods for experiment 5

<b>Skill</b>	<b>Observations and comments(Direct assessment of practical work skills)</b>	<b>Comments from the marked submitted practical work report.(in-direct assessment of practical work skills)</b>	
<b>A</b>	<b>Manipulative Area</b> A1 Manipulate effectively standard laboratory equipment	Poor manipulation of equipment where half of the six students under observation asked for assistance at one point or the other.  It was evident from their struggles that the six students under observation lacked basic skills of manipulation for example, poor reaction time.	The structure of this experiment was slightly different from the earlier two practical sessions in the mechanics section observed at schools <b>A</b> and <b>B</b> . According to the marked practical work reports observed students failed to score maximum marks on the asked questions because of the following reasons which include but not limited to:  Failure to justify the number of significant figures of <b>v</b> , Failure to estimate the percentage uncertainty in the values of <b>s</b> , Wrong calculated values of <b>v</b> , Failing to describe four sources of uncertainty or limitations of the procedure of the experiment, Failure to describe four improvements that could be made to the experiment.
	A2 Set up and use effectively the apparatus relevant to an experiment	Only three of the six students under investigation were able to effectively use the apparatus relevant to the experiment. One student could not effectively maintain position <b>A</b> as she was slightly beyond or behind <b>A</b> for different sets of readings. Two students were seen actually pushing the model vehicle instead of simply releasing it.	
	A3 Work accurately, systematically and with reasonable speed	Accuracy was mainly affected by:  Poor reaction time in starting and stopping the stopwatch at position <b>B</b> and position <b>C</b> ( observed on three students ),  Slightly changing the releasing point(position <b>A</b> ) for different sets of readings( observed on one student), Systematic error caused by friction because of an unoiled axle which affected the smooth movement of the model on the track (observed on one student).	Two students lost marks for failing to take relevant number of significant figures on the value of <b>v</b> . Two observed students did not score any mark on describing four sources of uncertainty of the procedure of the experiment. Only two students scored more than half of the marks on <b>g (i)</b> .  Half of the students observed managed to score at least half of the marks on describing any four improvements that could be made to the experiment. Two students failed

		Two students worked accurately, systematically and with reasonable speed.	to appreciate the importance of changing the value of $x$ to metres when calculating the value of $v$ and as a result got wrong values of $v$ . It was necessary for the students to realise the necessity of using SI units and symbols. Two students failed to show that, the value of $v$ was not affected by the changing values of $M$ .
B	<b>Observational</b>		
	B1 Observe accurately.	Wrong observations because of the noted sources of error recorded in <b>A3</b> above (observed on four students).  Two students had accurate observations.	At least half of the students were fairly good during the practical session but only two out of six observed students passed very well because the majority failed to answer questions g (i) and g (ii) that carried the bulk of the marks. In this experiment two of the observed students did not do well not because of very poor manipulative, observational, planning or designing but mainly because of poor presentation and analysis skills.
	B2 Record observations accurately.	Accurate recording of observations done by four students. Two students failed to appreciate the need for SI units on values of <b>S</b> which affected the correctness of calculated quantities <b>X</b> and <b>V</b>	
C	<b>Planning/Designing</b>	B3Read instruments correctly	This was not a problem to all the six students observed.
	C1 Plan an experimental procedure, applying standard laboratory techniques	Generally four of the six students observed failed to plan an experimental procedure in such a way that both random and systematic errors could significantly be reduced as noted in sections <b>A</b> and <b>B</b> above.	
	C2Modify established techniques to suit novel experimental situations	At least half of the observed students were not innovative enough to improve on the accuracy of the results. Examples include but not limited to taking repeated readings, tight fix of the block to the table and the board, use of a ticker timer, using rubber wheels among others. This was noted on the answers the students gave on suggestions for improvement.	

Table 4.5 gives a summary of the assessment done through both DAPS and IAPS giving finer details on the performance of the students on particular skills assessed. Four of the six students passed during direct assessment of practical work skills with a mark range of 50-70%. This was the same number of students who passed using the indirect method of practical work skill assessment based on the

submitted practical work report with a pass range of 50-70%. Of interest was the fact that only two students passed both through DAPS and IAPS with one getting 60% on DAPS and 70% on IAPS whilst the other got 50% on DAPS and 55% on IAPS. Only one student who passed through DAPS failed on IAPS where as two students who had failed through DAPS managed to pass through IAPS. The results show that the method that used to assess the students to a larger extent influence the mark that the student obtains more than the skills that are possessed by the candidate.

The six observed students showed minimal skills of manipulation, observation, planning and designing where a total of four out of the six managed to scratch pass marks during direct assessment of practical work skills. Manipulative skills proved to be a major challenge where three of the six students had ask for assistance to set up the apparatus. Poor reaction time by three of the six observed students was one of the challenges noted. Students either were too slow or too fast in starting and stopping the stop-watch at points **B** and **C** respectively (see excerpt 4.5). Two students were seen pushing the model instead of simply releasing it.

The models used by students were slightly different in terms of their smooth movement resulting in systematic error. This was caused by the fact that two of the models could hardly move because of friction due to lack of oiling of the axle. Despite this noted problem, the two students continued to use the models in that state, greatly affecting the results. Two students lost some marks because after failing to use the SI units of **S** resulting in wrong calculations of derived quantities. Poor reaction time affected the accurate recording observations. Four of the observed students failed to accurately plan an experimental procedure in such a way that both random and systematic errors could have been significantly reduced. This was mainly because of lack of innovation. In total four of the six students managed to pass during DAPS after taking an average score using a score range of 0-10 in the four areas of manipulation, observation, planning and designing.

A total of four students also passed from IAPS. The quality of the results was better considering IAPS to DAPS. The major challenges noted by the marker of the practical work reports were the inability by at least half of the students to do correct calculations, to answer questions on describing four sources of uncertainties or limitations of the experimental procedure and to describe four improvements that could be made to the experiment. Two students did not score a single mark on description of sources of uncertainties or limitations of experimental procedure. One failed also to score a single mark on describing improvements that could be made to the experiment.

The performance through both DAPS and IAPS showed lack of innovation and imagination on part of the student. There was a general lack of the ability to follow instructions as exhibited by the results from three of the students' practical work reports and comments made by the marker on this issue. The results show that the assessment criteria used did not reflect the abilities of the students in

mastering practical work skills as the final mark obtained by the student was influenced more by the method of assessment used than what the students had to show off their abilities to marry manipulative, observational, planning and designing skills to presentation skills. This is another case where realities of practical work assessment methods are compromised by possibilities of assessing the actual practical work skills mastered by ‘A’ level physics students because of the assessment criteria as summarised in table 4.5 for the experiment outlined in excerpt 4.5.

#### 4.7 Observations made during practical work session and comments from the marked submitted report for experiment 6

Experiment 6 as detailed in excerpt 4.6 was the second experiment students performed at school C under the observation of the researcher and the two research assistants. This experiment falls under the electricity section of the ‘A’ level physics syllabus.

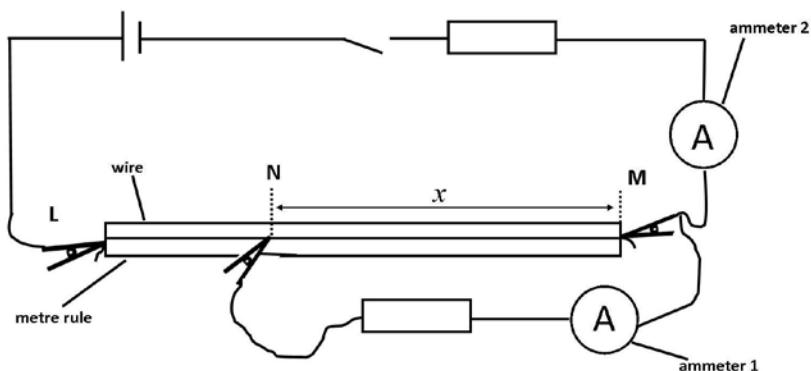
Excerpt 4.6: Investigating how current depends on the total resistance of the circuit

##### Excerpt 4.6

**You may need to use all of the materials provided.**

In this experiment, you will measure the currents at two different points in the same circuit and investigate how the currents depend on the total resistance of the circuit.

(a)(i) Set up the circuit as shown in Fig 1.1.



There are crocodile clips at L, M and N.

Place the crocodile clip at N so that the length  $x$  from N to M is approximately 60cm.

(ii) Measure and record the value of  $x$

$x.....$

(iii) Close the switch.

(iv) Record the current  $I$ , given by ammeter 1.

$I_1.....[1]$

(v) Record the current  $I_2$  given by ammeter 2.

$I_2.....[2]$

(vi) Open the switch.

(b) Change  $x$  and repeat (a) until you have six sets of readings of  $x$ ,  $I$ , and  $I_2$ , where  $x$  is in the range  $0.200\text{m} \leq x \leq 0.800\text{m}$ .

Include values of  $I_2$  and  $\underline{1}$  in your table.

(c) (i) Plot a graph of  $\frac{I_2}{I_1}$  on the y-axis against  $1/x$  on the x-axis [3]

(ii) Draw the straight line of best fit. [1]

(iii) Determine the gradient and y – intercept of this line.

Gradient = .....

Y-intercept = ..... [2]

(d) The quantities  $I_1$ ,  $I_2$  and  $x$  are related by the equation.

$$\frac{I_2}{I_1} = \frac{P}{x} + Q$$

Where  $P$  and  $Q$  are constants.

Using your answers from (c) (iii) determine the values of  $P$  and  $Q$

$P = \dots$

$Q = \dots$  [2]

Table 4.6 Comments on practical work skills assessment using the direct and in direct methods for experiment 6

Skill	Observations and comments(Direct assessment of practical work skills)	Comments from the marked submitted practical work report.(in-direct assessment of practical work skills)
A	<b>Manipulative Area</b> A1 Manipulate effectively standard laboratory equipment	Poor manipulation of laboratory equipment caused mainly by loose connections observed on two students. Ammeter readings were not stable.
	A2 Set up and use effectively the apparatus relevant to an experiment	Two of the observed students had to ask for assistance in setting up the circuit. One student got negative values of current after interchanging the terminals. Three students managed to correctly set up the circuit diagram without any assistance.
	A3 Work accurately, systematically and with reasonable speed	Three of the observed students were working accurately and systematically and with reasonable speed. The remaining three faced problems in setting up the circuit and one of the three because of poor choice of values of $x$ struggled to get a suitable scale for the graph.
B	<b>Observational</b>	

	B1 Observe accurately.	Three students had accurate observations. Two students had wrong values of X because of parallax error. This also affected values of $I_1$ and $I_2$ . One student took readings from the digital ammeters before they had stabilised.	students failed to notice that for a ratio of $I_2/I_1$ , there was no need to include units. Two students lost marks due to inconsistency in number of significant figures between raw values and calculated values.
	B2 Record observations accurately.	Three students recorded observations accurately while the other three students' recordings were affected because of the reasons noted in B1 above.	Observed students failed to score a maximum of 4 marks allocated for graphical work because of the following reasons: Failure to determine the values of the gradient and/or intercept, Missing plots on graph Failure to label the axes Missing graph title, Poor choice of scale.
	B3 Read instruments correctly	Three of the observed students read instruments correctly while the other three students' readings were affected by the reasons noted in B1 above.	
C	<b>Planning/Designing</b>		
	C1 Plan an experimental procedure, applying standard laboratory techniques	The instructions were clear and this resulted in three of the six students having a clear plan for the experimental procedure where they could easily and effectively apply standard laboratory techniques. Three other students observed struggled in this aspect.	Two of the observed students got wrong values of the gradient and intercept because of failure to correctly read off values on the graph or because of poor choice of scale. One student failed to plot all the points on the graph. One student failed to label the axes and the other included units for a ratio. Two students were quite good and scored at least $\frac{3}{4}$ of the marks allocated.
	C2 Modify established techniques to suit novel experimental situations	Half of the students observed lacked innovation to improve their experimental results.	Observed students failed to score a maximum of 4 marks allocated for analysis of results because of the following reasons: Out of range values of <b>P</b> and <b>Q</b> , Wrong units of <b>P</b> and <b>Q</b> , Failure to do analysis because of limited time, Wrong calculations.
			Two students obtained values of <b>P</b> and <b>Q</b> within range and the analysis was good. The two students scored 4/4 of the marks. One student scored 0/4 on analysis because of limited time to complete the write up. One student had wrong calculations for values of <b>P</b> and <b>Q</b> and the last two students had values which were out of range.

Five of the six students who participated in the study managed to get pass marks through IAPS whilst four of the six students managed to get pass marks through DAPS for experiment 6. Two students who had failed through DAPS managed to get pass marks through IAPS with one getting 40% on DAPS and 60% on IAPS while the other got 47% on DAPS and 60 % on IAPS. One student who managed to pass with a mark of 67% from DAPS managed to score only 35% through IAPS. Four students managed to get pass marks both through DAPS and IAPS with three of them scoring higher on IAPS than DAPS.

Half of the observed students experienced some challenges in manipulative skills to effectively do experiment 6 where in two cases students had to ask for assistance in setting up the circuit. Two students had loose connections which resulted in the instability of values of  $I_1$  and  $I_2$ . These students took the readings for  $I_1$  and  $I_2$  before the ammeters had stabilised in the process compromising the accuracy of the recorded values of  $I_1$  and  $I_2$ . Interchanging terminals resulted in one of the student getting negative values of  $I_1$ . This was also noted by the physics teacher who rectified the problem.

One student spent more than half of the one hour allocated for the experiment and the write up taking readings. As a result this student had limited time to do the write up and consequently failed on IAPS where the student got 35% after scoring 67% on DAPS. This student failed mainly because of poor management of time concentrating more on doing the experiment and failing to realise that the final mark was obtained from the submitted practical work write up. Three of the students however were working accurately and systematically with reasonable speed.

The other problem noted was accuracy in determining the values of  $X$  mainly caused by parallax error. It follows that if the value of  $X$  was not accurate then the values of  $I_1$  and  $I_2$  were also affected. This problem was observed on three students. The other three students who participated in study did not face any problem in this regard. Half of the students had a clear plan for the experimental procedure. These students could easily apply standard laboratory techniques. The other three students struggled in this aspect as they lacked innovation and imagination to improve on their experimental results.

The performance of students judging from the marked practical work reports was generally good. Five of the six students who participated in the study for experiment 6 managed to get pass marks after their practical work reports were marked. The participating students however lost some marks on results presentation mainly because of failure to take the required number of sets of readings, inconsistency in the number of significant figures between raw values and calculated quantities and missing units among others. One student calculated values of  $I_1/I_2$  instead of  $I_2/I_1$ . The other noted problem was the inclusion of units on  $I_2/I_1$  after two students failed to realise that it was a ration.

Despite these noted problems all the six students managed to score more than half of the marks allocated for data presentation. The students did not face much difficulty on graphical work with at least three students scoring more than half of the marks allocated on graphical work. Those who scored below half in this section faced problems of missing points on the graph, failure to label axes and poor line of best fit among others.

The worst performance by students whose marked practical work reports were observed was on results analysis where only two out of six students managed to score a pass mark in this section. One student did not score a single mark out of the four marks allocated because of limited time to work on this section. One student had wrong calculations for values of **P** and **Q** and the other two students had values of **P** and **Q** which were out of range.

Like in the other five experiments previously observed, the performance of students in terms of quality of results and the number of students who passed was better considering IAPS as compared to DAPS. This shows that the students had mastered their skills of presentation of results knowing that their performance was going to be judged from the quality of their reports than the ability to master practical work skills. This was evidenced by the fact that two students who had failed during DAPS managed to score pass marks from the assessment of their practical work reports.

#### **4.8 Rating of practical work skill mastery during observations against obtained mark from the submitted marked report**

This section compares the mark obtained by the student during direct assessment of practical work skills to that which was obtained by the student from the marked practical work report to establish any relationship that may exist between the two sets of marks for the same student and same experiment. This was done for a total of eighteen students who performed two sets of experiments each at the three schools resulting in thirty six sets of marks(N in this context refer to the number of observations). Table 4.7 gives a summary of the results and the statistical interpretation thereof.

Table 4.7 Grades obtained by students from DAPS and IAPS (**N=36**)

<b>Student experiment number</b>	<b>Rating as observed by the researcher in % (DAPS)</b>	<b>Obtained mark from the submitted report by the student as % (IAPS)</b>
<b>1</b>	67	90
<b>2</b>	43	65
<b>3</b>	30	45
<b>4</b>	43	55
<b>5</b>	60	95
<b>6</b>	67	40

<b>7</b>	47	65
<b>8</b>	70	45
<b>9</b>	43	75
<b>10</b>	67	80
<b>11</b>	33	46
<b>12</b>	43	70
<b>13</b>	67	72
<b>14</b>	63	44
<b>15</b>	37	61
<b>16</b>	56	70
<b>17</b>	50	39
<b>18</b>	40	70
<b>19</b>	60	61
<b>20</b>	47	28
<b>21</b>	50	39
<b>22</b>	73	61
<b>23</b>	60	44
<b>24</b>	43	33
<b>25</b>	60	70
<b>26</b>	50	55
<b>27</b>	37	50
<b>28</b>	40	55
<b>29</b>	70	40
<b>30</b>	53	45
<b>31</b>	63	65
<b>32</b>	67	35
<b>33</b>	47	60
<b>34</b>	77	65
<b>35</b>	40	60
<b>36</b>	57	50

The results presented in table 4.1 show that there is no clear linear relationship between the marks obtained by the student during direct assessment of practical work skills done by the researcher and the two research assistants as compared to those obtained by the student from the submitted practical

work report. In the majority of cases students who failed DAPS found themselves passing from IAPS. In some few cases, some students who had successfully progressed well from the DAPS would however fail the IAPS. Only 12 students out of 36 managed to get pass grades from both DAPS and IAPS.

From the marks presented in table 4.7 a scatter diagram as shown in fig 4.1 was drawn to establish any correlation between the two sets of marks for the same experiment assessed using two different methods of assessment. The random scatter of points shows that there is no relationship between the scores obtained by the student using DAPS as compared to IAPS.

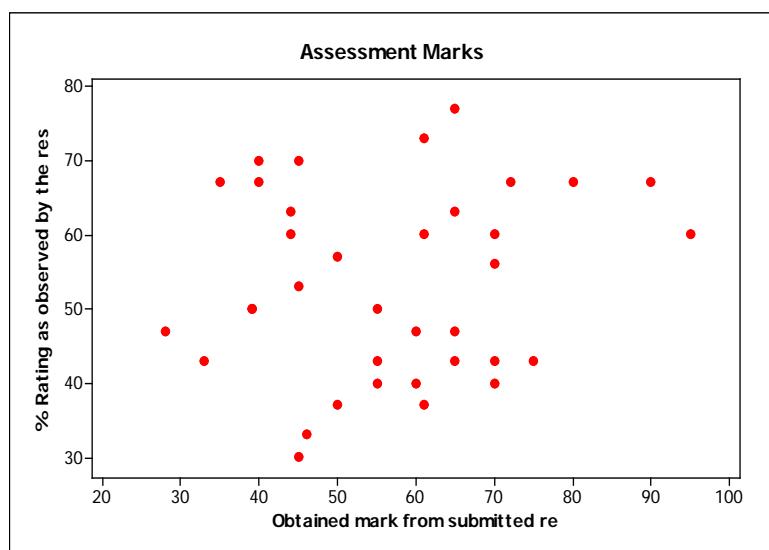


Fig 4.1 Scatter diagram showing the comparison of grades obtained by the student from DAPS and IAPS

This demonstrates that the methods used to assess the student's practical work skills would have bearing on the score obtained by the student as opposed to the practical work skills that may be exhibited by the student. This also shows the complexity which is associated with valid assessment of 'A' level physics practical work. The notion that practical work skills exhibited by the student can be inferred from the correctness of the values or results obtained by the student as advocated by Zimsec seem to be proved wrong by the results of this research. This is so because there is no linear relationship between the variables. The points on this scatter plot seem to float in space.

#### **4.8.1 Correlations: Percentage rating as observed by the researcher against obtained mark from the submitted practical work report**

Pearson's correlation coefficient ( $r$ ) of % rating as observed by the researcher and the obtained mark from submitted practical work report was calculated using SPSS version 22 and was found to be 0.135

with a P-Value of 0.432. Correlation coefficient is a technique for investigating the relationship between rating as observed by the researcher and obtained mark from the submitted report. Pearson's correlation coefficient ( $r$ ) is a measure of the strength of the association between the two variables. The correlation coefficient of 13.5% which was calculated in this case is very small compared to the threshold of 70%. Further, the t-test is used to establish if the correlation coefficient is significantly different from zero, and, hence that there is evidence of an association between the two variables, the P value (0.432) is large, implying that there is no reason to conclude that the correlation is real. There is no compelling evidence that the correlation is real and not due to chance.

In conclusion, the results indicate that the strength of association between the variables is very low ( $r = 0.135$ ), and that the correlation coefficient is very low insignificantly different from zero ( $P > 0.432$ ). This shows that, the correctness of the values obtained by the student as presented in the practical work report does not mean that the student had adequate skills of doing practical work during practical work sessions. Table 4.8 gives other statistical differences between marks obtained by the student from DAPS against those from IAPS as calculated using SPSS version 22.

Table 4.8 Statistical comparison of scores from DAPS and IAPS (N=36)

Type of assessment	Mean	St Deviation	Maximum	Range	Skewness	Kurtosis
DAPS	53.33	12.57	77	47	0.04	-1.13
IAPS	56.75	15.80	95	67	0.37	-0.19

The results show that students perform better from IAPS as compared to DAPS. The variation of marks was more pronounced on IAPS with a mark range of 67% as compared to DAPS where the range was found to be 47%. The maximum mark obtained by a student from DAPS was 77% as compared to 95% from IAPS. A normal distribution was approximated on IAPS as opposed to DAPS where data is left skewed with most values concentrated on the left of the mean and extreme values to the right.

The conclusion from this statistical data points to the fact that there is no relationship or association between the marks obtained by the student from DAPS as compared to IAPS. It might be untrue therefore to argue that, if a student produces a good report, it follows that the student had mastered other crucial practical work skills like manipulation, observation, planning and designing in addition to presentation and analysis skills. The results also show that the skills developed by the students are

greatly influenced by the assessment method employed as students performed better from practical work reports which only assess presentation and analysis skills than on DAPS where a variety of practical work skills are assessed.

#### **4.9 Comment on observational results: Relevance of the assessment practices on students' practical work skills development**

This section focuses on the discussion on observations made on the assessment of practical work using both DAPS and IAPS. Quite a number of trends emerged from the observations made through DAPS and IAPS from the six experiments done by students at the three schools that participated in the study. The major highlights on DAPS were mainly focused on the problems faced by students on manipulation, observation, planning and designing an experimental procedure. Students basically failed to effectively manipulate standard laboratory equipment mainly because of the failure to set up and effectively use apparatus relevant to the experiment. This was the trend with the majority of the observed students during practical sessions across the six experiments. Observed students were generally slow in doing the experiment where systematic and random errors could easily be noted mainly because of poor manipulation of equipment and in limited cases instruments that were not working well. As an example the majority of the observed students in some cases failed to do correct observations because of failure to read instruments correctly. The planning and designing skills of the majority of the students observed were not all that perfect as students failed to effectively plan an experimental procedure in order to come up with accurate results. The trend across the six experiments observed also indicated that students could hardly modify established techniques to suit novel experimental situations as they lacked innovation and imagination. Because of these common trends observed on the majority of students who were assessed using DAPS, the grades obtained by students on DAPS were generally lower as compared to IAPS. It brings an issue where students pass practical work examinations through IAPS without necessarily possessing the requisite skills to do practical work.

It is important to consider which skills students need to acquire that are useful in real life. According to Abrahams, Reiss and Sharpe (2013), the problem lies on how practical work must effectively and validly be assessed. The IAPS through the practical work report concentrates more on knowledge and presentation skills than assessing basic skills of manipulation, observation, planning and designing. Buick (2010:3) argues that it is important to assess skills rather than knowledge. As noted from DAPS students performed poorly because of lack of basic skills.

The situation was a bit different considering students' performance from the marked practical work reports. The observed trend from the students' reports on the six experiments performed was that

students were generally very good on results tabulation. The majority of the students scored above 75% of the marks allocated for results tabulation which in the majority of cases comprised about 40% of the marks allocated for the whole experiment. This naturally made it easier for the students to pass from the assessment of their practical work reports as they required very little marks from graphical work and result analysis to score a mark above 50%.

Students' performance on graph work was not as good as compared to result presentation as an observed trend from the practical work reports on the six experiments. Students struggled to score high marks mainly because of failure to label axes, wrong orientation of graphs, incorrect plots and in rare cases drawing a straight line instead of a curve. Five students across the experimental reports analysed failed to score some marks because of limited time to draw the graph. The worst performance was witnessed on results analysis where more than half of the students across the six experiments failed to score more than half of the marks allocated for result analysis. This was mainly caused by failure by students to apply mathematical concepts to find the unknown values as well as limited time to attempt to this last section of the experimental report. Despite all these problems, the performance of the students was far much better from the practical reports than direct assessment of practical work skills. The reasons might be due to the fact that students were quite aware of what there were expected to do when writing a practical work report as the marking points in the three areas of result presentation, graph work and results analysis are clearly outlined in the physics Zimsec syllabus (9188). This points to the fact that by religiously adhering to the expectations of the practical work report as prescribed in the physics syllabus, one may pass the practical examination without possessing basic practical work skills like manipulation, observation, planning and designing as evidenced by the observational results of this study through both DAPS and IAPS.

These partial results of the study on observations and document analysis of practical reports simply serves to show the need to develop effective and efficient procedures for assessment of practical work. It is important to bear in mind however that there is no simple way to assess students' practical abilities reliably and validly. The matter of assessing practical work remains a key issue in physics education.

Summative assessment of practical work narrows the number of skills students are assessed on according to Dillon (2008). Gopal and Stears (2007) observe that all learning outcomes cannot readily be tapped through tests alone as a means of assessment. An integrative approach need to be considered where different models of practical work assessments are to be combined to get the best out of practical work skills assessment. Abrahams and Millar (2008) refer to this kind of assessment as the embedded system which entails the use of both DAPS and IAPS. Erickson and Meyer (2003) warn that discrete assessment of practical work activities might result in the loss of some important

aspects where different skills interact with each other. It is the assessment method that influences how practical work in science is taught and done according to Abrahams and Millar (2008), Abrahams and Saglam (2010) and Abrahams and Reiss (2012). There is need to encourage breadth and variety in practical work skill assessment.

## CHAPTER FIVE

### TEACHERS' VIEWS AND PRACTICES ON THE ASSESSMENT OF PHYSICS PRACTICAL WORK

#### 5.1 Introduction

This chapter presents findings from and analysis of the interviews that were conducted to two 'A' level physics teachers at each of the three schools that participated in the study. Qualitative approach was employed in this chapter. A narrative approach (Creswell, 2007) was used in data analysis where in some cases direct quotations of what the respondent would have said were used to present the findings before analysis. Conservation analysis (Gray, 2011) was also used to analyse interview data as a complimentary technique to the narrative analysis. Conservation analysis according to Gray (2011) is interested in formal analysis of conservations and seeks to specify the formal principles and mechanisms with which participants express them during interaction. Towards the end of this chapter a discussion of the results from interviews was done under the sub topic '*Comment on teachers' views on the assessment of physics practical work*'. The two 'A' level physics teachers who participated in the study at each school comprised one who was taking the lower sixth (also referred to as form five) and the other taking the upper sixth( also referred to as form six). Table 5.1 gives a summary of the bio data of interviewed teachers.

Table 5.1 Bio-data of teachers who participated in the interviews

School	Teacher	Qualifications	Teaching Experience	Zimsec examinations marking experience
A	1	<ul style="list-style-type: none"><li>• Master of science education(physics)</li><li>• Bachelor of science education(physics)</li></ul>	17 years	4 years
	2	<ul style="list-style-type: none"><li>• Bachelor of science honours(physics)</li></ul>	4 months	0
B	1	<ul style="list-style-type: none"><li>• Bachelor of science honours(physics)</li><li>• Post graduate diploma in education</li></ul>	4 years	0
	2	<ul style="list-style-type: none"><li>• Bachelor of science honours(physics)</li></ul>	6 years	0
C	1	<ul style="list-style-type: none"><li>• Bachelor of science education(physics)</li></ul>	20 years	11 years
	2	<ul style="list-style-type: none"><li>• Bachelor of science education(physics)</li></ul>	13 years	3 years

The highest qualification of teachers who participated as indicated in the table was a master's degree in physics education. All the teachers who participated had at least a bachelor's degree in physics as per Ministry of Primary and Secondary Education requirement for the minimum qualification needed

to be eligible for ‘A’ level physics teaching. Two teachers who participated did not have any teaching qualifications despite being holders of bachelor’s degrees. Three teachers did not have any formal training for marking Zimsec physics examinations whilst the other three had at least three years’ experience of being Zimsec markers. The participants had varied teaching experience ranging from as little as four months to as much as twenty years. The purpose of conducting interviews to the physics teachers was mainly to get their views of the teachers on issues raised by research questions one to three.

*Research Question 1: How do ‘A’- level physics teachers assess practical work skills of students during the course of their programme?*

The structured interview administered to two ‘A’ level physics teachers at each of the sampled schools was important in addressing this research question. This research question was addressed through asking questions on how physics teachers assess students’ practical work skills during and after the practical work sessions (refer to questions 4, 5 and 8 in appendix 2).

The researcher also wanted to find out from the physics teachers whether Zimsec prescribed the method of practical work assessment to schools or whether the assessment of practical work used by Zimsec in the final examination forced teachers to employ the same methods of assessment during the two year ‘A’ level course.

*Research question 2: How relevant are the assessment practices on students’ practical skills development?*

This research question was addressed by interview questions 6,7,8,9 and 10 from the interview schedule (refer to appendix 2). The researcher wanted the views of the physics teachers on the relevance of the Zimsec’s prescription of practical work assessment in developing practical work skills of ‘A’ level physics students. The researcher also wanted to find out from the physics teachers the reasons for not assessing students as they carried out practical work activities rather than simply relying on the submitted practical work report as the basis of their assessment.

*Research question 3: What are the possible alternatives to physics practical work examinations?*

This research question solicited for physics teachers’ views on the alternative methods that can be used in the assessment of physics practical work in view of the challenges they would have highlighted using the current method of practical work assessment. This research question was addressed by interview questions 11, 12 and 13 on the interview schedule (refer to appendix 2). Physics teachers’ views were important in developing a new model of practical work assessment with the possibility to replace in part or in full the current practices of practical work assessment by Zimsec.

This chapter is divided into six sections:

5.1- Introduction.

5.2 - Assessment of practical work skills by physics teachers.

5.3 - Teachers' views on the relevance of the assessment practices on students' practical work skill development.

5.4 -Teachers' views on possible alternatives to physics practical work examinations.

5.5-Emerging themes from interview data

5.6 - Comment on teachers' views on the assessment of physics practical work.

## **5.2 Assessment of practical work skills by physics teachers**

Section 5.2 solicits for teachers' views and practices on the assessment of physics practical work using both DAPS and IAPS. The findings on this important aspect on teachers' practices on the assessment of physics practical work are presented in sections 5.2.1 to 5.2.6.

### **5.2.1 School A: Teacher A1**

The first teacher to be interviewed at school A is a holder of a master's degree in science education and a bachelor's degree in science education majoring in physics. The teacher had teaching experience of seventeen years of which sixteen have been spent teaching 'A' level physics. The first part of the interview solicited for the teacher's responses on the methods of practical work assessment employed by physics teachers at 'A' level.

Teacher A1 indicated that he uses both DAPS and IAPS during the first term of the lower sixth form and there after resorts to IAPS where he simply mark the submitted practical work report where the performance of the student will be based on the mark obtained from this report. Teacher A1 has this to say when asked about the practical work skills that he assesses his students during practical work sessions:

*Yah... basically what I try to do is during the first term of their form 5 the skills which I am concerned with are on planning, manipulation and more importantly data presentation and data analysis because basically at the end of the day you find Zimsec focuses more on these aspects. There after I will simply be marking the practical work report.*

The insinuation of this teacher suggests assessment of learners in physics maybe influenced by the desire of the teachers to pass the learners in practical work examinations. This is done at the expense of inculcating basic practical work skills like manipulation, designing, planning and observation in

students during the course of their programme. This argument is emanating from the fact that the physics teacher confessed that more emphasis is put on data presentation and analysis as students' assessment of practical work is based on the submitted practical work report.

Teacher A1 also noted that, DAPS during practical sessions was simply done as a corrective measure than using the scores to contribute to the practical work term mark as this mark was based solely from that which was obtained from the marked practical work report. Teacher A1 has this to say when asked about the possibility scoring students during practical work sessions:

*It's a great idea but we rarely practice it because it is not the way at the end of the day how Zimsec assess students' practical work skills. We are under pressure from the school authorities to ensure that students pass examinations and as a teacher, I employ those techniques which I think will assist the student to pass the examination.*

This quotation reaffirms the desire by physics teachers to ensure that students master presentation and analysis skills in order to pass examination at the expense of other equally important practical work skills.

### **5.2.2 School A: Teacher A2**

The second teacher to be interviewed at school A is a holder of a Bachelor of Science honours in physics. Unlike teacher A1, teacher A2 did not have any professional qualification and had served for only four months. This showed a big difference as compared to teacher A1 who had more experience, professional qualifications and a higher academic qualification. Despite the vast differences in terms of experience and qualifications, the researcher managed to get vital information on the issues under interrogation.

Teacher A2 was asked about the practical skills that he assesses the students during practical work sessions and he has this to say:

*I do assessment on how students handle apparatus not for the purpose of scoring them but assisting them in mastering practical work skills*

Teacher A2 does not necessarily score students during practical work sessions but assists them to develop practical work skills that are vital to obtain correct results. The assistance that is given during practical work sessions is to ensure that the students will produce good practical work reports which are used as the basis of assessment. The reasons given by the teacher for not scoring students during practical work sessions were mainly based on the factors of time and manpower. Teacher A2 argued that more time would be needed to effectively assess students. Teacher A2 also pointed out that there was need for more teachers to assist in the assessment as it could not be done by one teacher alone.

Teacher A2 however acknowledged the importance of scoring students during practical work sessions in developing practical work skills of an ‘A’ level physics student.

### **5.2.3 School B: Teacher B1**

The first teacher to be interviewed at School B had four years teaching experience. Teacher B1 is a holder of a Bachelor of Science honours degree in Physics with a minor in computer science. When asked whether at any point he assesses students as they do practical work activities, teacher B1 has this to say:

*I do not assess students during practical work for the purpose of scoring them but I however assist them here and there to develop hands on skills especially in cases where the students will not be familiar with the equipment they will be using during practical sessions.*

The teacher acknowledged that the practical work report would be used as the basis of assessment in line with the practices of Zimsec on the assessment of ‘A’ level physics practical work. Teacher B1’s argument was that any deviation from the practices of Zimsec on the assessment of practical work during the course of the students’ programme will prejudice their preparation hence the need to stick to the method that is used to assess students’ practical work skills during the final examination. Teacher B1 noted that the only worry during practical work session was to ensure that students had a correct set up of equipment. Teacher B1 at School B had this to say:

*I just give them the assistance on how to carry out the practical er, if it is a set up.... I monitor the student so that he or she presents ... er ... a good set up for the ... eer practical.*

Teacher B1 noted however that if the student’s practical set up is wrong, the teacher simply correct it without deducting any marks from the report. This is not in line with the practices of Zimsec as marks are deducted from the report if the student is assisted during the practical work session of the final examination. Asked why he was noting doing it the Zimsec way, the teacher argued that if that practice is put into effect during weekly practice, practical work sessions then students will not be willing to ask questions, in the process de-motivating them. Teacher B1 further argued that this was a deliberate move to encourage students to ask questions so that they get prompt assistance. Teacher B1 however noted that he was going to employ the practice towards final practical work examination.

### **5.2.4 School B: Teacher B2**

Teacher B2 to be interviewed at School B had six years of teaching experience. The teacher graduated from the University of Zimbabwe with a Bachelor of Science Honours degree in physics. Teacher B2 is yet to do a teaching qualification like a post graduate diploma in education. When asked about whether the teacher assesses students during practical sessions, Teacher B2 has this to say:

*I do the assessment but I do not do the scoring...first I assess time management and assist accordingly... second... aah is the identification of apparatus... some are able to identify the apparatus as mentioned in question paper and some are able to follow instructions in terms of setting up while some struggle...I will be moving around ... aah ... checking on those but not actually scoring marks.*

Teacher B2 actually supervises students as they performed practical work activities than assessing them. According to Teacher B2, this is done to ensure that the students have good time management skill, could easily manipulate equipment and are able to set up electrical circuits .From his experience, the teacher noted that the students often face problems in setting up circuits and this was one area where they needed a lot of assistance. Unlike Teacher B1, Teacher B2 indicated that he will deduct two marks when marking the practical work report for every student assisted. The argument from Teacher B2 was that this was going to encourage students to try to come up with a correct set up knowing that marks were going to be lost if assistance was sought. Asked if this was not going to discourage students from seeking assistance despite the fact that they could find it difficult to set up the circuit, Teacher B2 responded that through his supervision of students during practical work, he will simply assist those students whom he would have seen doing the wrong thing even if they did not ask for assistance. This was only done during weekly practice experiments as in the final examination the teacher was only allowed to assist those who asked for assistance.

It can be noted from the practices of Teacher B2 that the emphasis on the assistance was mainly on ensuring that the circuit was connected correctly without much attention on observational skills like recording observations accurately and reading instruments correctly for instance avoiding the parallax error. The issue of effective manipulation of laboratory apparatus for instance by ensuring that tight connections were necessary in order to get stable readings was never mentioned.

### **5.2.5 School C: Teacher C1**

Teacher C1 at School C was the most experienced teacher of all the teachers who participated in the study with ‘A’ level physics teaching experience of over twenty years. The teacher trained in Cuba under the Zimbabwe-Cuba teacher training programme and graduated with Bachelor of Science Education in physics. Teacher C1 is also a trained Zimsec marker with eleven years marking experience. Teacher C1 was asked on whether he assesses students and score them as they do practical work or simply wait for the practical work report for marking. This is what he had to say:

*Aah... normally I wait for the practical report because you find that the handling and manipulation of instruments, I always do that at initial stages then eventually when I start assessing I will be assessing the final report.*

Teacher C1 said that the manipulation and handling of equipment is normally done once at the beginning of the practical course considering that almost the same equipment is used for practical work. This may apply to practical work in the electricity section where the common apparatus are connecting wires, circuit board, voltmeter, ammeter, ruler, potentiometer, bulb or resistors. The situation is quite different when considering practical work in the mechanics section where each practical will have unique equipment where the teacher needs to ensure that the students are capable of handling them. It appears from the statement by the teacher that little emphasis is put on ensuring that the students have adequate skills of manipulation, observation, planning and designing since this is done only at the “initial stages” and thereafter Teacher C1 concentrates on presentation and analysis skills for grading the students. The teacher confessed that he was not much interested in how the student handled the equipment but more concerned with the presentation and analysis of results. Asked on the assistance that he normally gives to students during practical work or tests, Teacher C1 had this to say:

*Normally if they are misusing or misreading the instruments, aah, when they are failing to make connections to the appropriate components, I will chip in.*

Teacher C1 noted that he assisted those extreme cases where he doubted whether the student was going to get a result at all. He however acknowledged that marks were not deducted for the assistance rendered to students during practical sessions as it was a learning process. Teacher C1 also hinted on the dangers of deducting marks when help is offered during practical sessions as this discouraged students who will be doing the wrong procedures from asking for assistance from the teacher.

### **5.2.6 School C: Teacher C2**

Teacher C2 at School C had thirteen years’ experience of teaching ‘A’ level physics. Teacher C2 is a university graduate holding a Bachelor of Science with Education in physics. Teacher C2 is also Zimsec marker with three years marking experience. Asked whether the teacher assesses and score students during practical work sessions through DAPS, Teacher C2 has this to say:

*Yah... sometimes especially with the first part of the session or when like presenting or introducing the practicals, I give assistance to the students but not necessarily scoring them.*

Teacher C2 was further asked on the kind of assistance that he offered to the students during practical work sessions and this is what he had to say:

*During practical test if there are like electricity practicals usually we give them assistance whereby we have to firstly check if they have connected the apparatus correctly and then make the first reading only but usually for other practicals which are for mechanics we don’t.*

From the two statements given by Teacher C2, firstly the teacher assists students on equipment handling when practical work is introduced to the students. Students are not assisted on planning and designing skills as the focus is manipulative skills. Secondly Teacher C2 does not score students as they do practical work but mainly rely on the submitted practical work report for grading the students.

Teacher C2 pointed out that it was important to deduct marks for the assistance given to a student during practical work session when marking the practical work report as a way of preparing them for the final examination. Teacher C2 also pointed out that he administered Cambridge past practical examination papers to his students as the type of questions asked and the methods of assessment are similar.

Basically the kind of assessment which is done by the six physics teachers interviewed is the same. The teachers put more emphasis on result presentation and analysis than assessing students for the purpose of scoring them during practical work session. The major difference noted however was on the issue of deducting marks on the practical work report for the assistance given during practical sessions. The teachers gave very strong points on either side for their reasons for deducting or not deducting marks for the assistance rendered to students during practical work sessions. In a nutshell physics teachers are not much worried about how students perform during practical work session but their scoring is based on the mark obtained by the student from the practical work report as per Zimsec prescription.

### **5.3 Teachers' views on the relevance of the assessment practices on students' practical work skill development**

In order to address issues raised in research question 2, the researcher solicited for teacher's views on the relevance of the current practices of practical work assessment on skill mastery by 'A' level physics students. The views of the teachers are presented in sections 5.3.1 to 5.3.6.

#### **5.3.1 School A: Teacher A1**

In trying to get teachers' views on the relevance of IAPS as is the current practice by Zimsec and generally the method of assessment that is employed by teachers in schools, questions on the advantages of IAPS over DAPS were asked to teachers. Their views on the disadvantages of IAPS were also sought. The same was done on the advantages and disadvantages of DAPS. When Teacher A1 was asked about the advantages of IAPS this is what he had to say:

*Umm you see for example I can talk of cost cutting. I think cost cutting measures because it will be very difficult because maybe you need more resources to really observe students doing practical work and scoring for in your programme session like what you were saying you cannot look at 8 to 10 students at a go you might need 2 or 3 assistants.*

From the statement by Teacher A1, it is clear that despite some disadvantages that maybe obvious, IAPS is employed by teachers as a cost cutting measure considering that more resources are needed in terms of human capital if DAPS is used. These resources according to the teacher may be in form of adequate equipment, time, laboratory space, and transport among others.

Asked on the practical skills that the teacher assesses from the practical work report, Teacher A1 has this to say:

*Emphasis is on presentation of their work. At the table, I normally look for the presentation, have they drawn a table? Labelled some columns? The columns, do they have correct units ?,the data inside the table, has it been repeated? , is it consistent? Is it precise? On the graph there is labelling of titles, there is line thickness. The student, has he plotted all the points that are in the table or has he jumped some points?*

Teacher A1's statement is just but an extract from the 'A' Level Physics syllabus on the guidelines on practical work assessment points as clearly explained in chapter 1. The way Teacher A1 marks the practical work report is the same method that is used by Zimsec in the final assessment of 'A' level physics practical work. The assessment is therefore based on the mastery of presentation and analysis skills than the ability to manipulate, observe, plan and design experimental procedures.

Asked whether practical work report gives a true reflection of the skills gained by the student during practical work session, Teacher A1 has this to say:

*It's a fair indication of following instructions but not of handling equipment or assembling. It's just an indication of how best a student has done but the process of the practical might not be clear, you are just marking someone whom you have not seen doing the practical activity.*

It is clear from the teacher's statement that the practical work report is not an accurate document to use to assess students' practical work skills through inference as it does not give a true reflection of students' mastery of all practical work skills. Teacher A1 pointed out that it was possible for a student to pass practical work from the assessment of the practical work report even though the student would have failed to accurately do the practical work activities. Pressed by the researcher how this can be a possibility Teacher A1 has this to say:

*A clever one just knows the pattern, someone just knows that when doing this thing, the pattern is like this and this and can simply write down the rest of the figures , from theory he can get a results but these are rare cases. It requires an intelligent person.*

It was clear from the Teacher A1's sentiments that the current method of practical work assessment is prone to abuse by intelligent students. With good interpretive skills one can pass practical work

examination without necessarily possessing the basic skills of manipulation, observation, planning and designing.

Teacher A1 has this to say on the advantages and disadvantages of DAPS:

*The advantage of deploying examiners is that, surely you can see whether the candidate, is good at practical work. You will see him down at the ground and be able to assess. The disadvantage maybe is on the abuse of the system. That system maybe abused. Some people are not honest. If someone just wants the kid to pass, they may just load some marks on him. It becomes a disadvantage, sort of. If people are objective it will work*

In spite the fact that DAPS results in the assessment of quite a number of practical work skills, Teacher 1 was worried by the fact that if a team of assessors come to assess the students, this could create an intimidating atmosphere which could result in the panicking of students. Teacher 1 stressed on the need to train students to be confident to avoid stage fright in the event that students are assessed directly as they will be doing practical work. On another note Teacher A1 said that alternatively, the student may want to show off to the assessors that he or she is good. This is what Teacher A1 had to say:

*If they know that's the way we are going to assessed, then it is ok, they will be fine. Just like in a football match they know I am playing here, I want to win. So they also try to do that. I think it is another way because they want to prove they are really good just like a game of soccer, a game of basketball, they know they are being watched in a competition, I have to win. So it is another way, I think it is quite noble.*

From the sentiments by the teacher after weighing the advantages and disadvantages of DAPS, it is clear that Teacher 1 favours DAPS as compared to IAPS. It must be noted however that Teacher A1 down played issues to do with logistical problems as well as resources in terms of equipment and human capital associated with DAPS. It can be said in conclusion that Teacher1 sees IAPS not having much relevance in developing practical work skills of 'A' level physics students.

### **5.3.2 School A: Teacher A2**

To find Teacher A2's views on the relevance of IAPS in developing practical work skills of 'A' level physics students, questions on the advantages and disadvantages of both DAPS and IAPS were asked. This is what Teacher A2 has to say on the advantage of IAPS:

*There is the notion of time. It is possible for one teacher to assess many students through the practical work report which is not the case when students are assessed whilst doing the practical. Also another advantage is on design practicals. The design practical gives an excellent view of how innovative and creative a student can be, without necessarily having the actual equipment to do the model.*

Teacher A2 sees the advantage of IAPS as being hinged on the issue of manageability, where it is logically possible for one physics teacher to assess many students through IAPS. This might be a challenge to the physics teacher if the assessment of practical work skills is done directly. Teacher A2 also highlighted that it requires less time to asses students using the practical work report. The other noted advantage by Teacher A2 was on the design practical component. Teacher A2 argued that if a student is theoretically given a list of apparatus and asked to explain how he or she can design a working model, it will assist the student to become creative .Unlike a student who is given the actual equipment and asked to develop a model probably through trial and error, in this case a student is required to explain how he or she will design a working model. This according to Teacher A2 trains the student to be innovative.

Asked about the challenges associated with IAPS through the practical work report, this is what Teacher A2 had to say:

*A student who is bright may face ... eeh ... a bit of challenge in the practical examination and with that small mistake, that small challenge a student will fail. A student can also fail because of panicking.*

From this statement Teacher A2 was simply highlighting the dangers of assessing students' practical work skills in a once off situation as the student may fail because of panicking or that the student will not be feeling well on the day of practical work examination.

Asked on the possibility of passing the practical work examination from the assessment of the practical work report even though the student would have struggled during the practical work session, this is what Teacher A2 had to say:

*Well the for the current Zimsec one, it is possible. It has been a possibility that even if they don't do the practicals well... aah ... and just present their things well, eer they can pass of course. These students can pass the practicals just by the way of presentation. This is because there are no like for the markers, hidden cameras nor video recordings to see that the work that has been presented has some positive relation with the practical activities which were done in the laboratory.*

The statement by Teacher A2 serves to show that if students master their presentation and analysis skills, there is a possibility of passing practical work examination from the practical work report marking. The statement confirms the notion that the practical work skills that are assessed and scored to determine the grade obtained the student are not necessarily a reflection of the skills that are possessed by the candidate. It shows that the current way of practical work assessment is flawed hence the need to completely change it or argument it with alternative methods of practical work assessment.

### 5.3.3 School B: Teacher B1

This section presents the views of Teacher B1 at School B on the relevance of the current method of practical work assessment in developing practical work skills like manipulation, observation, planning and designing in addition to presentation and analysis skills. To get Teacher B1's views, the researcher started by asking Teacher B1, the advantages of IAPS. This is what Teacher B1 had to say:

*I think the main advantage of this system just prepares students for an advanced maybe university or college practical presentation. It just teaches them how to present their practical results, how to represent the results maybe on the graph **handiti** (a shona word meaning ok), so its main advantage is just teaching them to properly present their work.*

It can safely be concluded from Teacher B1's sentiment that, by assessing students' practical work skills from practical work reports, the system is only sharpening students' presentation and analysis skills. Students therefore will ensure that they perfect their presentation and analysis skills in order to pass examination at the expense of other crucial practical skills that they may need beyond the four walls of the 'A' level physics laboratory. Whilst it is important to first perfect skills like manipulation, observation, planning and designing in order to come up with perfect results, the situation on the ground points to the fact that more effort is put on presentation skills according to Teacher B1 at School B.

This is what Teacher B1 had to say when asked about the challenges associated with indirect assessment of practical work skills:

*Er, er ... this aah system seriously lacks aah, the hands on assessment practices. The current system of assessment which is being used by Zimsec to assess students is mainly concerned with the write up. Yes, with a proper write up skills, a student can score even more than 14 out of 18 after failing to properly do the experiment.*

Teacher B1 is simply echoing the sentiments previously noted by the two teachers at School A that, with the current system of practical work assessment, it is possible for the candidate to pass without necessarily having the basic practical work skills. This shows the invalidity of the current method of practical work assessment used by Zimsec in developing other practical work skills of 'A' level physics students besides presentation and analysis skills. Alternative methods of practical work assessment in light of these concerns by important stakeholders like physics teachers need to be considered. It is not only the duty of these physics teachers alone to think of these alternative methods but it requires a range of stakeholders including the students themselves, parents, tertiary institutions and the industry at large to bring about change. Any change normally comes with a cost hence the need to involve different stakeholders.

The current way of practical work assessment emphasises on the ability by the candidate to follow instructions from the observations by Teacher B1. In other words Teacher B1 simply realises that the current way of practical work assessment limits the range of skills that maybe assessed on an ‘A’ level physics student. Teacher 1 noted that the number of marks that are lost by the student for getting inaccurate values is so insignificant that it is possible for an incompetent student to pass practical work considering that normally only four marks out of the possible twenty for the whole experiment are allocated for obtaining an accurate value. The Zimsec practical work marking scheme is not much worried about the correctness of the data per say but with the correctness of the method of data presentation

Teacher B1 noted that DAPS was a more effective way of assessing students’ practical work skills. This is what Teacher B1 had to say on this issue:

*It teaches, I mean aah, important skills in physics. The student will acquire the skills during his or her 2 year course on how to do physics practical work perfectly. Direct assessment gives a true reflection of the student’s ability or level of operation when doing practical work. Maybe some students are naturally good when handling equipment than on writing practical work reports.*

Teacher 1 is an advocate of DAPS as compared to IAPS judging from his sentiments. Asked about the disadvantages of DAPS Teacher B1 confessed that he cannot think of any. From his judgement, Teacher B1 seemed to be overwhelmed by DAPS to the extent that he could not think of any disadvantages.

#### **5.3.4 School B: Teacher B2**

Teacher B2 was the second teacher to be interviewed at school B. In this section, Teacher B2’s views on the relevance of the current method of practical work assessment are presented and comments thereafter made. Asked on the advantages of IAPS this is what Teacher B2 had to say:

*On part of the student, if the student is quite good with following instructions, then the student will get away with good marks even if the student did not correctly perform the practical. This is an advantage to the student and not the teacher or the system.*

Teacher B2 is bringing in a new scenario which was not discussed before. Teacher B2 was of the idea that when talking about advantages, it is important to highlight whether the advantage is to the student or the system as represented by the physics teacher. However Teacher B2 echoed the same sentiments as in previous interviews that if the student is good at following instructions, it highly possible that he or she will pass the practical work examination which is assessed through the practical work report. This according to teacher B2 is an advantage to the student and not the system which wants to produce an ‘A’ level physics graduate who has mastered basic practical work skills like manipulation,

observation, planning and designing in addition to presentation and analysis skills. Asked on the challenges teacher face when marking practical work reports, this is what Teacher B2 had to say:

*Aamm, in order for me to mark correctly, what somebody has done I will have to carry out the whole experiment on my own. I will write it up on my own and compare with the marking scheme. Sometimes you will find that what the student would get is not exactly what you are getting and like if you look in the previous practical that you assessed about two students they had negative gradients and they were supposed to be positive gradients. To come up with a marking scheme it's involving. It's like you will also be writing the examination just like students.*

Teacher B2's point is that there is no way a teacher can mark the physics practical work report using the marking scheme from the past examination paper only, without first doing the practical work activity. According to Teacher B2, this system gives a lot of work to the teacher in preparing for the practical, look for relevant equipment and perform the experiment before one can mark students' practical work reports. This according to Teacher B2 is different when direct assessment of practical work skills is used where the teacher simply relies on the marking scheme. Teacher B2 was quick to point out that one of the students who had obtained a negative gradient instead of a positive one managed to score a pass mark. It was a clear way of showing the problems that are associated with IAPS despite the student having missed out during the practical work session.

Asked about the possibility of detecting cheating through "cooking" of results by students during practical work, this is what Teacher B2 had to say:

*Mmm ...indirectly I have found it difficult but each and every part that I have managed to do the marking scheme on my own I have managed to detect the cheating, you can detect the cheating, you can even say this value, this is not the correct value and if you ask the student they even start smiling acknowledging that they have been caught.*

This according to Teacher B2 is one weakness of assessing practical work skills through the practical work report because students can cheat and sometimes it will be very difficult to find out. Students who have not mastered a range of skills may find themselves passing the practical examination because of good presentation skills.

Asked about the teacher's emphasis on practical work assessment, Teacher B2 has this to say:

*I emphasise the ability of the student to follow instructions. That is my number one emphasis. Imagine if you are just given something that you have never seen, you have seen the apparatus you have never seen before .Something like that just comes on the examination day, the one who will score marks is the one who can follow instructions because if you follow instructions then you are ok.*

It follows therefore that students are drilled on the tricks of passing the examination than being equipped with practical work skills that are crucial at destinations beyond the ‘A’ level physics laboratory. Students do practical work in order to pass examination than developing practical work skills reading from the statement by Teacher B2. Teacher B2 also expect students to tabulate and draw graphs as per guidelines from Zimsec as outlined in the ‘A’ level physics syllabus on the section on practical work assessment. Teacher B2 also pointed out that, the practical work report does not give a true reflection of the skills gained by the student during practical work session. This is what the teacher had to say:

*You can still get the correct values without even using the proper skills .Some persons can even cheat, clever students those that are a bit genius, if they got probably two set of values which are far away from each other, they can theoretically interpolate the other values and they can get away with it . Students can ‘cook’ results.*

Teacher B2 went on to say that some marking schemes just emphasise on getting some results and not necessarily accurate results and if these results are presented according to Zimsec’s prescription on result tabulation and analysis, then according to Teacher B2 that student is likely to pass.

Asked about the advantages of DAPS, this is what Teacher B2 had to say:

*This now will produce students who are able to do practical work instead of just indirect assessment because you will be able to see exactly how someone is carrying out the practical and marks are awarded for setting up equipment, observations and planning among others. That will add value to the practical work activities that we are assessing at the moment. You can produce someone who can go further and be able to do their own things.*

According to Teacher B2 DAPS will create a product with life skills that are crucial after the two year ‘A’ level physics course. DAPS will result in having a graduate who is innovative. Asked about the disadvantages of direct assessment of practical work skills, this is what Teacher B2 had to say:

*It’s an expensive way of doing things but it’s a good way but though in an expensive way. The student will benefit but for the system now, it’s something that must have a good budget for it to be successful. The other issue or disadvantage that can come there is the issue of,... you know with schools the issue of pass rates that might result in corruption and subjective assessment unlike marking practical work reports which is objective.*

This point raised by Teacher B2 is very important as also noted by Abrahams, Reiss, and Sharpe (2013), that it is difficult to objectively assess practical work using the DAPS. The other problem on DAPS raised by Teacher B2 was on the issue of students panicking if they are assessed by external examiners. Teacher B2 managed to raise pertinent issues that were not raised before by earlier

respondents. In a nutshell Teacher B2 seems to agree with previous respondents that IAPS is not of much relevance in developing practical work skills of advanced level physics students.

### **5.3.5 School C: Teacher C1**

Teacher C1 at School C, despite his vast experience in teaching and marking ‘A’ level physics practical work, was rather reserved when asked about the advantages of assessing practical work using practical examinations. This is what he had to say:

*Um... aah because we are now accustomed to that kind of assessment so we are no longer interested in change.*

This is an old school type of teacher who is not interested in any change believing that any change in the way practical work is assessed will bring about new problems. Because of his vast experience of assessing students’ practical work skills using practical work reports, Teacher C1 sees an advantage of a tried and tested system of practical work assessment as he argued that any change in the way practical work is assessed may bring about new problems. When further asked about the envisaged disadvantages of IAPS, this is what Teacher C1 had to say:

*Er... sometimes... er... we always encourage our students to do the correct results as they do the practical, although we might suspect that results can be ‘cooked’. This might happen if students fail to adhere to instructions especially related to calculating quantities.*

Teacher C1 was simply trying to explain that this method of practical work assessment is prone to cheating by students as they are chances of manipulating the results in order to pass. Despite that resistance to change, from experience Teacher C1 is aware of the fact that student can take advantage of the system to find their way to a pass mark. Teacher C1 also noted a very important point on the ability to follow instructions. Analysing Teacher C1’s statement, those students who are able to follow instructions are likely to pass the examination. It follows therefore that this method of practical work assessment examines the student on limited number of skills, mainly on the ability to follow instructions, presenting and analysing results.

Asked about areas of emphasis when assessing practical work, this is what Teacher C1 had to say:

*Normally I always encourage students to take readings correctly from measuring instruments and then present them down correctly in their format in terms of tabulation, graphical work and result analysis. They should follow the procedure wanted by Zimsec. Normally they should do that in the stipulated time frame.*

Teacher C1 is more concerned about presentation and analysis skills when assessing students’ practical work skills. The teacher was silent on other important skills that need to be considered when

assessing students' practical work skills. These skills may include manipulation, observation and designing among others. The emphasis mainly is in the ability to follow the procedure of result presentation and analysis as outlined in the Zimsec syllabus.

From his experience and opinion, Teacher C1 was asked about whether or not the practical work reports mirror the skills of the candidate during practical work session. This is what Teacher C1 had to say:

*Not exactly. Er... from the Zimsec marking scheme I think the student can pass with the wrong results as they would have processed the results in a way wanted by Zimsec. This can be, for example by correct calculations, plotting of the graph, calculation of the gradient intercepts and so forth or even calculation of the constants from wrong results. Sometimes you find that the student can pass just like that.*

Despite resisting change Teacher C1 is quite aware of the weaknesses of practical work assessment currently used by Zimsec. It is clear from the sentiments by Teacher C1 that the practical work report does not give a true reflection of the skills inhibited by the student during practical work session.

When asked about the advantages of DAPS, this is what Teacher C1 at School C had to say:

*Yes, assessment of many skills that cannot be done from a practical report. You find that some schools just drill students for the practical work examinations during the third term. They just drill them towards examination.*

Teacher C1 noted that through direct assessment of practical work skills, more skills can be assessed on students. Teacher C1 had stunning revelations that some schools do not do practical work throughout the two year 'A' level physics course reserving it for the final term. Normally schools should have a two hour practical session every week in accordance with science departmental policy. It becomes surprising and saddening to learn that some schools simply drill students towards the final examination. Definitely students will not have enough time to develop other crucial practical work skills as the teacher will be concentrating on those skills that are necessary for the student to pass practical work examination. Most of the practical work skills cannot be developed over night hence the need to expose students to different practical work activities during the course of their programme.

Asked about the disadvantages of DAPS, Teacher C1 pointed out that it required a lot of resources to implement it. Teacher C1 also noted that it was not possible for this method to be used in Zimbabwe considering the current poor economic position of the country. This is what Teacher C1 had to say:

*It's a noble idea but not financially and logically sound.*

When asked to further qualify the statement, Teacher C1 noted that it was impossible for Zimsec to get enough examiners at each school at the same time and date of the practical work examination. According to Teacher C1, this was so because the same teachers who qualify to be external examiners were also required at their schools during the same period. Teacher C1 pointed out that, there was a general shortage of ‘A’ level physics teachers in schools as some schools have Teachers with degrees in Computer Science or Engineering teaching ‘A’ level physics. It was most unlikely that Zimsec could get enough manpower to assess students directly as they do practical work. Teacher C1 was also concerned with the subjectivity associated with DAPS arguing that just like in IAPS it was difficult to actually assess the skills that could have been mastered by the student. As pointed out by other teachers who participated in the study, teacher C1 noted that student could fail DAPS because of panicking considering that a class of ten students would require at least five assessors. The number of assessors alone according to Teacher 1 could be intimidating to the students.

It may be concluded from the sentiments of Teacher C1 that despite the problems associated with IAPS and its irrelevancy in developing a variety of practical work skills of ‘A’ level physics students other than presentation skills, it was difficult at the moment to completely abandon the assessment method in Zimbabwe. According to Teacher C1, to some extent the method of practical work assessment used by Zimsec remains relevant as other options are beyond the reach of the country in terms of time and resources required for implementation.

### **5.3.6 School C: Teacher C2**

Teachers C2 at School C’s views on the relevance of practical work assessment method in developing work skills of ‘A’ level physics students were different from those of Teacher C1. When asked about the advantages of IAPS through the practical work report, this is what Teacher C2 had to say:

*I think the advantages are more to do with the exam board because it has to find a way of assessing practical skills. At the end of the day you find the only advantage is, they are able to produce a mark sheet to score what they think would have happened... right, it's easier for them .Yah, it's an easy way of assessing students but it may not be best.*

From the sentiments of Teacher C2, Zimsec use the IAPS for logistical reasons despite probably being aware of the disadvantages of the method which appear to outweigh the advantages. The method according Teacher C2 does not result in the assessment of a variety of practical work skills. According to Teacher C2 this method is used more as a way of cost cutting than a comprehensive method of practical work assessment.

Asked about the challenges associated with IAPS, this is what Teacher C2 had to say:

*I don't think it cultivates in the students this inquisitive mind of trying to design your own practical, plan your own practical and that ability to do your own practical. I also think that maybe if you look at these students, basically what they are able to do is perform practicals which they think are taken from the book right. When you ask them maybe to just design their own practicals, to investigate a certain aspect which you think because of the content which they have they can always try to use the little theory to design a practical, they fail to do it.*

What Teacher C2 is saying is that, the current method of practical work assessment does not encourage critical thinking and innovation in line with the current approaches of science pedagogy which are hinged on constructivism. It limits the potential of the students as they concentrate on mastering presentation skills in order to pass the examination. According to Teacher C2 this method of practical work assessment kills skills of innovation, designing, planning and manipulation as students are restricted by the demands of the physics syllabus. Teacher C2 does not solely blame the lack of innovation on the part of the student also arguing that the very teachers who are teaching physics today were trained using the same methods and as such teachers teach students the same way they were trained. This is what Teacher C2 had to say:

*Yah... in fact on that aspect, I think it also goes back to our training as teachers. We were also not trained to be innovative. Were we trained to be able to design our own practicals and so forth? I think it comes back to us also and lastly maybe, what I would say is I have never come across an instrument which emphasizes on assessment of psychomotor skills.*

Teacher C2 is pointing out on the ripple effect to his students of practical work assessment methods that were used when teacher was still a student. The system has always been using IAPS when assessing practical work which was inherited from the Cambridge International Examination Board. In a way it is difficult for Teacher C2 to assess the psychomotor skills of the students when the teacher was not exposed to the same methods of practical work assessment before.

Asked about emphasis of practical work assessment considering the current method used, Teacher C2 had this to say:

*The emphasis is on presentation of data. Are you able to present according to the prescription? Are you able to analyse the results which you have obtained right? Maybe lastly of course, they will try to ask the student to suggest possible improvements but rarely do they do that.*

The emphasis on practical work assessment according to Teacher C2 is clearly spelt out in the hard copy of the Zimsec syllabus and I was grateful to Teacher C2 for providing me with the copy as the soft copy on the internet did not have this section. Teacher C2 further had more to say on emphasis of practical work assessment considering the current system:

*Maybe let me try to put it this way. When you look at the skills gained right?, as to the skills related maybe to the cognitive aspect, I think basically it does well in trying to assess those but the manipulative skills or maybe should I put them under the psychomotor skills I don't think Zimsec is doing anything to assess those skills. I don't know maybe whether is it because it difficult to design an instrument to assess those or is it costly?*

Asked on the possibility of a candidate passing practical work examination even though one was not doing the practical work correctly, this is what Teacher C2 had to say:

*Yes, it is very possible. Basically if you look at the marking scheme on the first aspect it just emphasises, on ability to reproduce a set of data. Are you good at calculating the given values right? The second aspect, are you able to reproduce the column headings and so on? Are you able to do the calculations? Are you are able to recall the rules with regards to significant figures when doing calculations and so on? I think then graphical work, it's almost similar every time.*

If candidates adhere to expectations of Zimsec with regards to writing of a practical work report as clearly outlined in the Zimsec 'A' level physics syllabus then it will be very easy to pass the examination without necessarily having mastered basic practical work skills. This is because of the rubric which is associated with the presentation of practical work reports. Teacher C2 has this more to add on this aspect:

*You see the point, a student even if he/she has a completely wrong data set, as long as the student is able to plot the points, draw the graph, line of best fit and manipulate data, do the data analysis, they can pass. I think maybe mostly they fail on the data analysis aspect where maybe where they are expected to get given constants within a given range they may fail but you find its no more than 5 marks out of possible 18 marks so a student's who is good at all other aspects can get 13/18 which is a good mark.*

The statement simply serves to show the weaknesses associated with the current method of practical work assessment. When asked about the advantages of DAPS this is what Teacher C2 had to say:

*I think that type of assessment, if it were to be realised in schools in a way it develops the skills of being innovative, developing ability to improvise right? Where you cannot find equipment I think teachers can also try to improvise. To construct different instruments to just help in doing the practical report. The student must be able to apply the learned concepts in solving everyday life problems right? So every day's life problems are not solved theoretically. It's more of practical, what matters so, if you develop practical skills, I think you can survive.*

The teacher is arguing that if a variety of skills are assessed through DAPS, students are likely to master different practical work skills that are important in environments outside the school laboratory.

It will foster the development of life time skills than simply those skills that will enable the student to pass examination according to Teacher C2. When asked about the disadvantages of DAPS, this is what Teacher C2 had to say:

*The disadvantages which I might point out are, one, maybe lack of training on the part of the teachers on how we can assess such type of skills because of course yes I can see that maybe this student is failing to do this, failing to manipulate this and that ,right? But maybe there are other skills which I may not be in a position to assess because I have not been exposed to such type of assessment. The other disadvantage which I may think of is with regards to availability of equipment as more resources might be required.*

The major concern of Teacher C2 on the assessment of practical work during practical work session was on the danger of lack of assessment skills on the part of the assessor. This might not be a problem because if this method is introduced, definitely examiners will be trained. According to Hoe and Tiam (2010:1) Singapore embarked on a radical shift to School Based Assessment (SBA) breaking a long tradition of a once off summative practical examination of the Singapore-Cambridge General Certificate for the Advanced Level (GCE-A level). Before this shift was done, examiners were first trained and the project pilot tested. The same could be done if Zimsec thinks of venturing into alternative ways of ‘A’ level physics practical work assessment. The issue of resources was a concern of all the teachers that were interviewed as there is a need of both human and more equipment for the method to be successful.

From the sentiments of Teacher C2, it can be concluded that the current method of practical work assessment is not of much significance in developing a variety of practical work skills of ‘A’ level physics students. The method is basically beneficial to the examination board as it is a cheap and easy way of assessing practical work activities. Teacher C2 also alluded to the lack of skills on the part of physics teachers if new methods of practical work assessment are to be introduced. Teacher C2 also noted the possibility of cheating by students when practical work reports are used as the basis of practical work assessment.

#### **5.4 Teachers’ views on possible alternatives to physics practical work examinations**

This section presents teachers’ ideas on alternative models that can be used to compliment or replace the current system used in the assessment of ‘A’ level physics practical work. The ‘A’ level physics teachers who participated in the study were also expected to justify the reasons for the envisaged changes that they would like to see on the assessment of ‘A’ physics practical work. Teachers’ views at Schools A, B and C are presented in sections 5.4.1 to 5.4.6

#### **5.4.1 School A: Teacher A1**

When asked about the alternative models that can be used in the assessment of ‘A’ level physics practical work, this is what Teacher A1 had to say:

*I think continuous assessment. Like eee submitting the average coursework mark for the student during the programme and then they can average that mark with mark obtained by the student in the final examination. It's a checking and balancing act.*

Teacher at School A is of the idea that, students’ practical work skills must not be judged from a one off practical work examination as it will be difficult to assess all the practical work skills of the students. Teacher A1 is of the idea that the weekly practical work reports done at school must contribute towards the final mark obtained by the student in addition to that obtained in the final practical work examination. Asked about the course work weighting, Teacher A1 confidently said that the course work mark must contribute 50 % towards the final mark. If this method is to be employed then they will be need to standardise the kind of weekly practical work activities at all schools doing physics in the country. Probed on the possibility of teachers cheating by giving their students very high marks, Teacher A1 replied that he expected physics teachers to act professionally. Despite the obvious disadvantage of the abuse of system by some teachers, this appears to be a possible alternative to practical work examinations.

#### **5.4.2 School A: Teacher A2**

Teacher A2 suggested the inclusion of a practical work report on each student commenting on the way how each student planned the experiment, manipulated equipment and accuracy in taking of readings. Teacher A2 believed that the accompanying report will assist the examiner when marking student’s practical work report. Teacher A2 argued that the student will be given credit basing on report submitted by the teacher. If one closely looks at Teacher A2’s suggestion, it will be difficult for a single teacher to observe all the students on time and be able to write a comprehensive report for each student. The suggestion by Teacher A2 on the alternative way of assessing practical work, however appears to be noble one given that problem areas are identified and solutions found. Teacher A2 suggested that it is important retrain physics teachers on the assessment of practical work either at district or provincial level. This platform according to Teacher A2 is important as they can get an opportunity to share ideas on the assessment of ‘A’ level physics practical work. Teacher A2 also pointed out the need for practical examination to contribute more on the final assessment than the current 20%. This is what he had to say:

*Ok, ... look at our papers. We have five papers in physics and only one paper is the practical paper and the other four are theory. I think practical papers should be more than theory papers. There is need to emphasize on hands on considering the world of technology we are now living in.*

Teacher A2 is arguing that with the introduction of more practical work examinations, a variety of practical work skills can be assessed as compared to the current situation where we only have one paper. The alternative model of practical work assessment advocated for by Teacher A2 is a holistic approach where there is need for at least three practical work papers. One paper will be for IAPS through practical work report, the second paper will be for DAPS during practical work session and the third paper on the production of an artefact where a student design a model that can be put into practical use. Teacher A2 argued that, an 'A' level physics graduate currently produced by the system is full of theory without basic practical skills to solve societal problems. Teacher A2 argued also that this kind of approach will boost student's confidence at destinations beyond the 'A' level physics laboratory. Teacher A2 is more interested on the application of physics than theory and that can only be achieved if more weighting is given on practical work assessment than on theory to improve on hands on skills.

#### **5.4.3 School B: Teacher B1**

When asked about the alternative model of practical work assessment, Teacher B1 at school B considered a practical work assessment model where both DAPS and IAPS are used at 50-50% level. This is what Teacher B1 had to say:

*Yaa, I think the system should be refined towards direct assessment such that maybe the supervisor scores marks as the student performs the practical. Of course an attachment report should be made also available maybe now with a 50/ 50 score.*

Teacher B1 is advocating for the fusion of both IAPS and DAPS where half of the marks should be allocated on DAPS and the other half earned on IAPS. Teacher B1 also suggested the project method as one way of assessing students. The student will be expected to do a project over a period of two years where at the end of the two years the student will submit a report accompanied by an artefact. Teacher B1 also emphasised on the need for a practical paper on designing. According to Teacher B1 this paper would assist students in perfecting their design skills and probably come up with new inventions. The need for critical and technical thinkers cannot be over emphasized in physics and that can only be achieved if more emphasis is put on the development of psychomotor skills than concentrating on theory.

#### **5.4.4 School B: Teacher B2**

In light of the noted problems associated with practical examinations Teacher B2 had this to say when asked about alternative models of practical work assessment:

*Ok that's fine I get you. What I honestly think in addition to what is happening, we have a one day or two hour way of assessing someone for a two year course .Personally I would think that if you have got a project that someone can work on as a two year project that will bring about innovation unlike the two hour thing. The two year course project will allow the student to think probably within the confines of the syllabus to start with. They then produce whatever they produce and possibly demonstrate it to the examiners and they can be scored based on that. The current practicals must also remain. There is an issue of time management and following instruction. If we just drop it and adopt let's say the project, then what about time assessment and following instructions? When someone is doing a project he or she is free to ask whoever they want.*

Teacher B2 acknowledges the importance of the current system of practical work assessment where students submit a practical work report as it assists in the assessment of presentation skills, the ability to follow instructions and time management. Teacher B2 argues that because of the importance of these skills, the current method of practical work assessment cannot be completely dropped but must be complimented with alternative methods like the project. Teacher B2 also emphasised the importance of putting more papers on practical work than on theory. The teacher argued that the current scenario where there is only one practical work paper contributing about 20% of the total marks is not healthy in developing physics practical work skills. According to Teacher B2, physics is a subject that must be used to solve technical issues within the society and as such that can only be realised if more emphasis is put on practical work. Science is about practical work hence the need to accord practical work assessment the importance it deserves in the teaching and learning of physics. Teacher B2 said that he is saddened by a situation where a student can get an A in physics despite the fact that he or she would have failed practical work. The rationale of Teacher B2 was that scientists are known for their inventions which in most cases involve practical work. Teacher B2 is also of the idea of continuous assessment of practical work over the two year period where for each unit of the five major units in 'A' level physics syllabus practical work assessment need to be done through the project method. This is what Teacher B2 had to say:

*I think it's also another method that can work in terms of a two year course. Remember we have got five sections in our syllabus. Let's say the first section we make an assessment, on the practical work but basically on the issue of projects right? We have a project for section one and for each section up to section five. Five different projects that will be used to assess someone, then we got the final practical, I think we can produce a very good scientist.*

Teacher B2 however acknowledged that projects need more resources and time and as a result the method, though good on paper might be difficult to implement. In the event that the project method is used as way of assessing practical work, Teacher B2 noted that it is important to give more weighting to the project than the practical work report.

Teacher B2's views can be summarised by noting that, despite the need to consider new methods of practical work assessment, IAPS through practical work reports remains relevant. Not all practical work skills could be assessed using the alternative methods but the alternative methods are equally important if they are used to compliment the current method of practical work assessment. The other important point noted by Teacher B2 was the need to put more weighting on practical work assessment than on theory papers.

#### **5.4.5 School C: Teacher C1**

Asked about alternative methods of practical work assessment, this is what Teacher C1 at School C had to say:

*I think continuous assessment by the teacher and the teacher will then send the course work mark to Zimsec. The problem is that we adopted the Cambridge system of practical work assessment and we are afraid of change although Cambridge has transformed the way it is assessing practical work.*

Teacher C1 was simply acknowledging that, when Zimsec took over the responsibility of running secondary schools examinations from Cambridge board, the new examination board did not change the contents of the syllabus apart from coming up with a new cover design. Teacher C1 feels that with more than twenty years of 'A' level physics teaching experience, this is the time to introduce new methods of practical work assessment. According to Teacher C1 a system where course work marks are sent to Zimsec from schools is practised in practical subjects like woodwork, metal work and building and as such the same could be done in physics. Currently, physics practical work questions are taken from the electricity and mechanics section and Teacher C1 feels that there is need to consider other sections of the physics syllabus to come up with practical work questions. This is what Teacher C1 had to say:

*I know this one might be a burden for schools but I think the idea of assessing oscillations and the electricity only ya...a, I think it's not good. It does not give the much needed practical work skills to the student. I think the practical work should cover a wide range of the topics in physics and I think there must be a review of the design question.*

Teacher C1 is simply emphasising the importance of considering all sections of the syllabus when coming up with practical work questions. Unlike the idea of Teacher B2 at School B who advocated for mini projects from all sections of the syllabus as part of the assessment, Teacher C1 is proposing

five practical work questions from the five sections of the syllabus which must be assessed using the IAPS. Teacher C1 is also worried about the current way of assessing design practical where a student is given a hypothetical problem and asked to explain how he or she will design a practical to get a solution to it. Teacher C1 feels that it is necessary to give the explanation then give necessary apparatus to the student to carry out the design experiment.

Teacher C1 wants an increase in the number of practical papers administered during examination from one to two. Unlike the other four previously interviewed teachers who proposed that practical work need to contribute at least 50% of the final physics examination, Teacher C1 feels that theory papers need to contribute more than practical papers. Teacher C1 however feels that practical work weighting must be increased from 20% to 40 %. At least up to this point all the interviewed teachers are agreeing that the percentage weighting of practical work needs to be reviewed upwards. Teacher C1 also pointed out the importance of assessing the manipulative skills of the students than scoring students on tabulation of results and drawing of graphs.

#### **5.4.6 School C: Teacher C2**

When Teacher C2 at School C was asked about alternative models of practical work assessment, this is what he had to say:

*You see, the point now I believe in is, if each time students come in to do 'A' Level physics, as they go through their practical work and so on, each student should be given an opportunity to develop his/her own project which would be assessed over a two year period. I think that is one easy way of assessing, because it will combine the designing, the practical construction of whatever he has to do and so forth, so it will focus I think on all the aspects which are expected for a student to cover.*

Teacher C2 sees the use of the project method as one method that can be used to assess a wide range of practical work skills that cannot be assessed using the summative form through a two and half hour practical examination. Teacher C2 further proposes that the artefact that is produced need also to be accompanied by a report ensuring that both presentation and manipulative skills are assessed. This according to Teacher C2 will promote the development of presentation skills as well as planning, designing, manipulation and observational skills. Teacher C2 dismissed the idea of assessing students' practical work skills through course work because of cheating where subject teachers can easily fix marks because of pressure of producing good results. This idea is supported by Stacey and Spielman (2014) as they note that students typically receive higher marks for assessments marked by their teachers than for practical examinations. Teacher C2 rather proposes a model where internal assessment of the project is done by the subject teacher. Final assessment is then done by external assessors for the purpose of grading. Teacher C2 however noted that challenges of equipment and funding may affect the quality of the products produced as a student might have a very good idea but

might be forced to abandon it because of lack of equipment. Teacher C2 also noted that, this could force the student to do an inferior project depending on the availability of resources.

Teacher C2 was also concerned with the design practical where the students are simply asked to write a report on design aspects without necessarily carrying out the practical. Teacher C2 argues that it was important for the students to write a report as well as carrying out the design experiment. This is what Teacher C2 had to say:

*The changes I would also want to see have more to do with the design aspect of assessment. What I would have wanted is maybe they ask the student to design the practical then perform the practical. There is need to focus on design practical where equipment can easily be found.*

Teacher C2 generally advocates for continuous assessment of practical work through the project method of the two year period. Teacher C2 also wants to see a situation where students perform design practicals than simply writing a design practical report. The teacher is however aware of the financial demands associated with this kind of assessment and as such expects government to assist schools in providing the equipment.

### **5.5 Emerging themes from interview data.**

As way of summarising teachers' views and practices on the assessment of 'A' physics practical work skills, the following themes emerged from data presentation and analysis:

- Physics teachers rarely assessed students' practical work skills during weekly practical work sessions.
- Physics teachers employed DAPS during the first two practicals done at 'A' level during the first term to ensure that their students mastered skills in manipulation, observation, measurement and designing and thereafter relied on practical work reports for assessment.
- Physics teachers cited lack of adequate time and resources that include human capital, infrastructure and equipment as major reasons for not assessing students during practical work session.
- Despite the disadvantages associated with IAPS on the development of a variety of practical work skills of 'A' level physics students, the method was continuously be employed by Zimsec mainly because of its objectivity, cheapness and logically convenient as compared to DAPS.
- Physics teachers noted that the practical work report was not an accurate document to use to assess students' practical work skills through inferences. Physics teachers argued that the practical work report did not give a true reflection of students' mastery of practical work skills as there was a possibility of cheating by the student to pass practical work examination.

- Physics teachers pointed out that DAPS was more relevant in developing practical work skills of ‘A’ level physics students than IAPS though the teachers were of the general opinion that it was important to employ both models when assessing students’ practical work skills
- Physics teachers noted that DAPS was a too subjective method to accurately assign students grades during practical work sessions and also that corrupt and unprofessional examiners could easily inflate marks.
- Physics teachers proposed alternative methods of practical work assessment that include the project method, continuous assessment, practical portfolios and artefacts.
- Physics teachers proposed a new method of assessment in ‘A’ level Physics examination that gives at least 50% weighting to practical work assessment as compared to the current 20% contribution of practical work to the total assessment in Physics.

From these several themes only three themes emerged that directly addressed the three research questions:

*Research question 1*

How do ‘A’- level physics teachers assess practical work skills of students during the course of their programme?

*Research question 2*

How relevant are the assessment practices on students’ practical skills development?

*Research question 3*

What are the possible alternatives to physics practical work examinations?

These themes are:

- Physics teachers relied on practical work reports as the basis of assessing ‘A’ level students’ practical work skills
- Physics teachers noted that the practical work report was not an accurate document to use to assess students’ practical work skills through inferences. Physics teachers argued that the practical work report did not give a true reflection of students’ mastery of practical work skills as there was a possibility of cheating by the student to pass practical work examination.
- Physics teachers proposed alternative models of practical work assessment that embrace both DAPS and IAPS.

These major themes are discussed in detail in section 5.6 under the section ‘comment on teachers’ views on the assessment of physics practical work’.

## **5.6 Comment on teachers' views on the assessment of physics practical work**

This section focuses on discussion on teachers' views on the assessment of physics practical work. The views varied from one teacher to the other considering the six teachers who participated in the study. Some of the sentiments were however similar.

The first aspect was on practical work skills assessed by 'A' level physics teachers during practical work sessions. Teachers generally noted that they rarely assessed students during practical work sessions. The physics teachers rather relied mainly on the practical work report as a basis of their assessment. The 'A' level physics teachers had varied views and practices on the aspect of students' skills which they assessed during practical work sessions. Despite the different views, it appears that there were common aspects in their practices. Basically, the teachers noted that they employed DAPS during the first two practicals done in term one of the 'A' level physics study. Thereafter the teachers noted that they then resorted to IAPS.

This was mainly influenced by the fact that Zimsec uses IAPS method hence the teachers wanted their students to have adequate practice before they sit for the final examination. The way the physics teachers assess the physics students is influenced by the desire to ensure that students pass practical work examinations. This could only be achieved from the teachers' arguments if the assessment of practical work during the course of the 'A' level physics programme is done the way Zimsec will assess students in the final examination. DAPS was simply done by the teachers as a corrective measure than for the purpose of grading the students. The rationale for IAPS was done to ensure that students master their presentation and analysis skills which are crucial to them to pass the final examination at the expense of other equally important practical work skills like manipulation, observation, planning and designing. Buick (2010:14) emphasises, the need to assess skills rather than knowledge when assessing practical work. It is not possible to assess a wide range of skills through IAPS.

Results from the interviews show that teachers mainly relied on practical work reports submitted by students at the end of practical work session for the purpose of assessment. According to Gopal and Stears (2007:16) assessment is considered to be one of the most powerful influences on what and how teachers teach and what and how learners learn. It is necessary to come up with assessment techniques that strike a balance between the affective and cognitive domains. A review on the assessment of practical work found that countries considered to be high performing economically and technologically use substantial portion of direct assessment of practical skills as compared to those who rely on IAPS according to Abrahams, Reiss and Sharpe (2013).

This study is important to Zimsec to consider alternative ways of assessing 'A' level physics practical work than solely relying on the submitted practical work report as the basis of assessment. The use of

a variety of methods of practical work assessment will assist students in developing various skills unlike the current scenario where the concentration is on presentation and analysis skills. It is important to come up with assessment techniques that strike a balance between DAPS and IAPS.

Physics teachers also cited lack of adequate time, resources and manpower as major reasons for not assessing students during practical work sessions. Reiss, Abrahams and Sharpe (2012) argue for the need to fully utilise the laboratory environment to develop manipulative, investigative and design skills in students in addition to presentation skills. Through the assessment of practical work reports, the focus is more on what the students know about practical work than on their competences in terms the practical work skills they have. There is need to develop effective and efficient strategies and procedures for practical work assessment according to Bell and Cowie (2001). This can only be achieved if more emphasis is put towards skill based assessment.

Teachers who participated in this study said that during practical sessions, they do not score students as such but ensured that students have good time management skills as some students fail to complete the practical write up after spending a lot of time doing the practical. Teachers emphasised the importance of moving around during practical sessions, checking on how students handle equipment and set up apparatus. The supervision was necessary to ensure that students had good time management skills, could easily manipulate equipment and be able to set up electrical circuits. Nadji, Lachi and Blanton (2003) argue for a holistic assessment of practical work from lab based activities to practical work write ups.

Teachers who participated in the study debated whether or not physics teachers must deduct marks if a student asks for assistants during practical work session. Proponents of deduction argued that it was important to deduct marks from those who asked for assistance so as not to prejudice those students who could do the practical without asking for assistance. The further argument was that it encouraged students to think critically on the best way of doing the practical bearing in mind that if they asked their teachers' assistance, then marks were going to be deducted. Proponents also argue that since this was the same system employed by Zimsec in the final examination, it was necessary to train students in the same way during weekly practical work activities at schools. Opponents however argue that since it is a learning process it will not be necessary to deduct marks from students since this will demotivate them. The further argument was that this could discourage students who will be doing the wrong procedure from asking for assistance defeating the whole purpose of learning. Arguments from both parties were however sound and valid and it is necessary from the researcher's view for the teacher to use his or her own discretion to deduct or not to deduct marks depending on the extent of the help rendered to the student.

The second section of the interview addressed issues raised in research question 2 which solicited for teachers' views on the relevance of the current practices of practical work assessment on skills mastery by 'A' level physics students. Interviewed teachers noted that IAPS was done as it was necessary to cut down costs involved in practical work examinations though it did little in assisting students to develop key practical skills like measurement, observation, planning and designing apart from presentation and analysis skills. Reiss, Abrahams and Sharpe (2012:6) note that IAPS has a disadvantage that its validity is very low and is less likely to raise students' level of practical skills though it has an advantage that it is more straightforward for those who undertake the assessment. IAPS has an advantage to the assessors in terms of easy logistical arrangements, timeframe, cost, objectivity among others but it rarely, really assesses a variety of practical work skills that are expected to be mastered by 'A' level physics students. IAPS limits the range of skills that can be assessed. IAPS is however more objective when assessing practical work skills compared to DAPS.

Physics teachers also noted that, the practical work report is not an accurate document to use to assess students' practical work skills through inference. Interviewed teachers argued that the practical work report does not give a true reflection of students' mastery of practical work skills. Students can cheat when assessed through practical work report and sometimes it will be very difficult for the teacher to detect it according to the observations made by experienced physics teachers who participated in the study. According to Reiss, Abrahams and Sharpe (2012:6), IAPS focuses more on what the students know about practical work than on their competency in terms of how they actually carry out practical work activities.

Current methods of practical work assessments are prone to abuse by students according to arguments raised by physics teachers as students can "cook" out figures on the table of results from the pattern and trend of the results. Physics teachers noted that DAPS has as an advantage that more practical work skills of the students can be assessed using this method. The interviewed teachers were however quick to note that the system cannot solely rely on DAPS as it is expensive in terms of equipment and human capital as well as time management. Reiss, Abrahams and Sharpe (2012) notes that DAPS has disadvantages in that, it is more costly, requires teachers and others to be trained to undertake the assessment and has greater moderation requirements. Interviewed teachers highlighted the dangers of abuse of the system of DAPS by teachers who may act unprofessionally. The concern was that corrupt teachers could simply award high marks to some students as it is difficult to check on consistency when DAPS is employed unlike in IAPS where a practical work report is submitted as the basis of assessment. Another case raised by physics teachers on DAPS was that students could panic if the assessment is done by external assessors. A team of assessors according to the interviewed physics teachers could create an intimidating atmosphere.

The teachers noted that DAPS was more relevant in developing practical work skills of ‘A’ level physics students than IAPS. Observations by Abrahams, Reiss and Sharpe (2013:12) are that, China, Singapore, New Zealand and Finland often described as high performing countries all make use of a substantial proportion of direct assessment of their students’ practical science skills at some point in their schooling system. Treagust (2008) criticises practical work examinations as a means of assigning students to their grades in a summative manner.

The physics teachers generally were of the opinion of using both DAPS and IAPS methods as a means of assessing students’ practical work skills. Mathews and McKenna (2005) concluded that the matter of assessing practical work remains a key issue in Irish education as elsewhere. Reiss, Abrahams and Sharpe (2012:32) note however that while it is clearly impossible to teach the full range of practical skills that every employer and higher education institution desires enabling school students to gain experience of a reasonable number of major practical skills will benefit them far more than having no such experience at all. Despite the fact that the use of DAPS appears to have more advantages on the student over IAPS, the strategies must not be used as competitive models but complimentary assessment methods. There is need to encourage breadth and variety in practical work assessment according to Lavonen and Laaksonen (2009).

To summarise teachers’ views on the relevance of practical work assessment method on the development of practical work skills of students, Abrahams, Reiss and Sharpe (2013:228) has this to say: “If the intention is to determine competence, then direct assessment is the best, whereas if the intention is to determine skill process, then indirect assessment would be the preferred option”. Lunnetta, Hofstein and Clough (2007:399) note that using IAPS, teachers are less inclined to devote time and effort to develop students’ practical skills. DAPS creates a product with life skills that are important beyond the ‘A’ level physics course despite the expenses in implementing it at school level.

The third research question solicited for teachers’ views on possible alternatives to physics practical work examinations. The interviewed teachers were also expected to justify their choices of alternative models. ‘A’ level physics teachers advocated for continuous assessment of practical work through course work. The formative assessment was preferred as a way of ensuring that a wide range of practical work skills could be assessed over the period of the two year course than trying to assess all the practical work skills during a two and half hours final practical examination. This idea of formative assessment of practical work is supported by Fairbrother (2008) as he asserts that “only teachers can see students in action and assess their objectives, which are directly connected with their practical work and this is where they should be directing their time and effort”. Ideally, assessment should provide short term feedback so that obstacles can be identified and tackled very early within the process of learning. Black and William (2004:140) assert that “formative assessment is not an

instrument on an event but a collection of practices with a common feature that all lead to some action that improves learning". It means if practical work is assessed continuously through course work, students have an opportunity of improving on their practical work skills as they get feedback from teachers in areas where they might be facing problems.

The physics teachers proposed that both DAPS and IAPS were to be employed during continuous assessment of practical work through course work. The Physics teachers also proposed that the course work would contribute 50% and the final examination which also needs to be assessed using both DAPS and IAPS contributing another 50% of the final mark. Dufresne and Gerace(2004) note that the rationale for formative assessment is to effectively monitor and influence the development of students' thinking process, inquiry skills, attitudes towards science and learning behaviours.

Another alternative according to the views of the teachers was to introduce more practical work papers so that more practical work skills could be assessed. Considering the current 'A' level physics syllabus (9188), the final examination structure comprises four theory papers and one practical paper that contribute about 20% of the final mark of the student. The suggestion was that practical work mark needs to contribute more than 50% of the final 'A' level examination by having three practical work papers out of the five papers. The argument was that considering the current structure a student can pass 'A' level physics examination after performing dismally in the practical work examination since it contribute about 20% of the final examination. Downs (2013:1) however warns that practical work is a core skill in science such that proposals which would allow pupils to fail their practical assessment and still achieve excellent grades in science are unacceptable. Physics is a practical subject as such its assessment must reflect its practical nature. The three proposed papers according to the physics teachers who participated in the study could employ both DAPS and IAPS. This could assist in the assessment of a variety of practical work skills. Sentamu-Namubiru(2010:311) identifies that learner diversity requires the implementation of various assessment strategies as different learners may demonstrate the achievement of different outcomes in a variety of ways.

The third alternative proposed by the physics teachers was the project method where at the end of the two year course, the students will be expected to produce an artefact as well as the project report. The assessment will be based on the functionality of the artefact as well as a submitted report on how it was designed. The project method according to the views of the interviewed teachers could produce innovative 'A' level physics students. This could not be the case if only practical work examinations are administered. According to Cakir (2008) constructivist approaches must promote conceptual changes and development through use of activities. Treagust and Duit(2008) argue that constructivist science education is humanistic in nature and it aims at supporting the development of individuals' personality. Students must be empowered to deal with challenges of their future lives. This can only

be achieved if students are afforded the opportunity to design their own projects that will form the basis of practical work assessment. Treagust and Duit (2009:89) note that “constructivist teaching approaches consider students’ beliefs and conceptions towards student centred pedagogy in science instruction with the focus on students’ interest, their learning skills and their needs in actively constructing their knowledge”.

Considering the three models of practical work assessment proposed by the physics teachers, emphasis was on the use of both DAPS and IAPS through a system that incorporates course work and final examination. The interviewed teachers managed to adequately respond to the three research questions which are:

- How do ‘A’- level physics teachers assess practical work skills of students during the course of their programme?
- How relevant are the assessment practices on students’ practical skills development?
- What are the possible alternatives to physics practical work examinations?

The views of the physics teachers are useful in coming up with a proposed model of practical work assessment that will assist students in developing a variety of practical work skills.

## CHAPTER SIX

### STUDENTS' VIEWS ON THE ASSESSMENT OF PHYSICS PRACTICAL WORK

#### 6.1 Introduction

The narrative approach (Creswell, 2007) and conservation analysis (Gray, 2011) were used to present and analyse data from focus group discussions (FGD) with 'A' level physics students. Qualitative approach was employed in this chapter. Preliminary discussion of the results of the FGD is done towards the end of the chapter under the sub-topic, '*Comment on students' views on the assessment of physics practical work*'. All the upper sixth students doing 'A' level physics at each of the three schools which participated in the study were involved in FGD. This was so because physics at 'A' level is done by very few students in Zimbabwe as compared to other subjects which in this case the highest number in a group was fourteen. Table 6.1 gives a summary of the bio-data of students who participated in the study.

Table 6.1 Bio-data of students who participated in FGD

School	Number of Female Participants	Number of Male Participants	Total
School A: Group 1	4	9	13
School B: Group 2	3	8	11
School C: Group 3	0	14	14
<b>Total</b>	7	31	<b>38</b>

A total of seven girls participated in FGD at the three schools as compared to thirty one boys. At all the three schools that participated in the study, the number of boys was larger than that of girls. The age range of students was between 16 and 18 years. The purpose of conducting FGD with 'A' level physics students was mainly to get views of students on issues raised in research questions one to three.

*Research Question 1: How do ‘A’- level physics teachers assess practical work skills of students during the course of their programme?*

As way of triangulating and validating the information obtained through administering interviews to ‘A’ level physics teachers, it was important to get the opinion of the students on the assessment of physics practical work skills. The focus group discussion questions addressing research question 1 solicited for students’ views on the assistance they get from physics teachers and how this impacted on the assessment of their practical skills by the teacher. Students were asked on issues to do with the assessment of practical work skills during practical work sessions.

*Research question 2: How relevant are the assessment practices on students’ practical skills development?*

This research question was addressed by focus group discussion questions 4, 5 and 6 (refer to appendix 3). The focus group discussion questions solicited for students’ views on whether it was possible to pass practical work because of good presentation skills though they would have failed to do the correct procedures during practical work session. The FGD generally solicited for students’ views on the relevance of the current practical work assessment methods in developing a variety of practical work skills of ‘A’ level physics students.

*Research question 3: What are the possible alternatives to physics practical work examinations?*

This research question was addressed by focus group discussion questions 5, 6 and 7 (refer to appendix 3). The research question solicits for ‘A’ level physics students’ views on the alternative methods of physics practical work assessment, stating the advantages and disadvantages of the alternative model. This chapter is divided into five sections:

- 6.1 – Introduction.
- 6.2 - Assessment of students’ practical work skills.
- 6.3 - Students’ views on the relevance of practical work assessment method.
- 6.4 - Students’ views on possible alternatives to current physics practical work assessment method.
- 6.5 - Comment on students’ views on the assessment of physics practical work.

## **6.2 Assessment of students' practical work skills**

Students were asked to express their views on how practical work is assessed and also to state the practical work skills that they develop over the two year course. Students' views on these aspects are presented in sections 6.2.1 to 6.2.3.

### **6.2.1 School A: Group 1**

Students who participated in the FGD at School A were asked to express their views on how practical work is assessed and the practical work skills they develop during the course of their study. The students at School A noted that the physics teachers did not do any assessment during practical work sessions leaving the job of supervising students during practical work sessions mainly to the laboratory technician. The students noted that the teachers were mainly interested in marking the practical work report that was submitted at the end of the practical session. The idea of trusting the laboratory technician with the responsibility of supervising students during practical work sessions is a bit worrisome. The laboratory technicians might not be competent enough to give proper assistance to the students during practical work sessions as their job is basically to prepare practical equipment.

Students noted that it was important to develop practical work skills that will assist them to pass 'A' level physics practical work examination. These skills mentioned by students were mainly presentation and analysis skills. This is what one of the students had to say:

*It is important to consider a number of things in order to pass practical work examination. You need to consider errors, zero error and other errors. It is also important to know unit conversion and convert all units to SI units. You need also to consider the number of significant figures when doing calculations. You need also to be able to interpret the graph...er... the ability to calculate the intercept and the gradient.*

From the sentiments of the student in group 1, it can be noted that the student is more worried about the presentation and analysis skills like tabulation of results, graphical work and result analysis than other skills like manipulation, planning and designing. Three out the four skills mentioned by this student have to do with presentation and analysis of results. These were the sentiments of most of the students who participated in the focus group discussion in group 1. One student however considered skills to do with manipulation, planning and designing to be more important in order to pass examination. This is what another student in group 1 had to say:

*I think before carrying out each and every practical we need to be well versed on how each and every instrument is used so that we won't find ourselves confused on how to use an instrument in an examination, so we need to have some lessons to use all the instruments used for practical work*

*purposes. You also need to consider measuring techniques to get rid of the parallax error as well as taking repeated readings to avoid random errors.*

This student is acknowledging the importance of having good manipulative, designing and planning skills in order to come up with accurate results. Unfortunately when the practical mark report is being marked only about four marks out of a total of about twenty marks are allocated for accuracy. It is however crucial to note that the student is aware of the importance of developing a variety of practical work skills in order to pass practical work examination than simply concentrating on presentation and analysis skills. The students also mentioned time management as one aspect which is important when doing practical work as there was the need to balance the time of actually carrying out the practical activities with that of doing the practical write up.

The students in group 1 basically noted that the assessment of practical work is based on the submitted practical work report where the assessment is mainly on results presentation, graphical work and results analysis. The students in group 1 bemoaned the lack of practical work revisions by physics teachers as one reason why they failed to perfect their practical work skills. The students said that the teacher simply mark the practical work reports and rarely afford them time to do revisions together for future improvement on performance.

### **6.2.2 School B: Group 2**

Students at School B were asked about how the physics teacher assesses their practical work skills and also about the practical work skills they need to have in order to pass examination. Students who participated in the FGD had varied views about these issues. The students however concurred on the fact that physics teachers rarely assessed them during practical work sessions as the teacher mainly relied on the submitted practical work report for assessment. The students revealed that there were mainly assisted by the laboratory technicians during practical work sessions where the physics teacher would only chip in, in situations where the technician was unable to solve the problem. The students who participated in FGD in group 2 mainly emphasised the importance of possessing good manipulative and presentation skills in order to pass examination. This is what one student in group 2 had to say on the importance of having good manipulative and observational skills in order to pass ‘A’ level physics practical work examination:

*I think you must be fast, especially in mechanics section. You must be alert for example when timing oscillations to get the period. In electricity you need to make sure that you have set the circuit correctly and one should be a little bit more precise in taking readings to avoid error of parallax.*

Students who participated in the FGD were aware of the importance of possessing good manipulative, observational and measuring skills in order to pass examination. Students were worry of the issue of

taking an appropriate reading on an analogue multimeter where one was to be sure of the scale range as this could result in the recording of wrong readings. Despite the fact that students' assessment of these skills was based on the practical work report, some argued that by correctly doing the experimental procedure, this in a way boosted their confidence on compiling a good practical work report. According to the students, this will also assist them in avoiding silly mistakes in tabulation, graphical work and ultimate analysis of results.

More emphasis was put on presentation and analysis of results as students were quite aware of the fact that the bulk of the marks were scored from presenting a good report than on following the correct procedure during practical work sessions. This is what one student had to say:

*On the table I think you should put your measurements to 2 decimal places, all your reading should be to the correct decimal places. Units should also be included in the table depending on the quantity for example mass in kilograms. I think your presentation must be neat.*

The student was quite aware of the need to be consistent on the number of decimal places when recording readings on the table as well as having correct units on column headings in order to score high marks on result tabulation. This is what another student who participated in group 2 had to say on the important skills to possess in order to pass practical work examination:

*I think you must not leave out headings on the graph, fully label it with units and accurately draw a line of best fit which is not very thick at the same time having almost equal number of points on either side of it.*

Students were aware of the importance of drawing a neat and well labelled graph in order to score high marks which in most cases contribute about 30% of the total marks that can be scored by the student from the practical work report. Nothing was said on the importance of taking the correct gradient and intercept in order to do precise calculations of unknown quantities from group 2. Students also revealed that in cases where they were stuck during practical work sessions, they could ask for assistance from their teacher. The students also acknowledged that their teacher does not subtract marks when marking the practical work report in the event that one asked for assistance during practical work sessions as the teacher believed that this was a learning process.

Basically, students who participated in group 2 said that physics teachers only supervised them during practical work sessions as the assessment was based on the submitted practical work report. To a larger extent students said that it was important to have good presentation and analysis skills to pass examination though they were quite aware of the need to have equally excellent manipulative, planning , observational and design skills in order to achieve that.

### **6.2.3 School C: Group 3**

Most of the issues noted by group 1 and group 2 on the practical work skills that a student must have in order to pass examination were similar to what students in group 3 said. Students in group 3 however noted that, occasionally their physics teacher awarded them some marks for a correct experimental procedure as well as good manipulation of equipment as a way of encouraging them to come up with accurate results unlike the case with group 1 and 2. Unlike in group 1 and 2, students who participated in group 3 also said that their laboratory technician was not involved in assisting students during practical work sessions as that was done solely by the teacher. The duty of the technician was to simply assist in bringing in alternative equipment in cases of faulty ones or bringing in more consumables. Further investigations as to why the situation was different compared to the other two schools showed that the technician at this school was not qualified hence the physics teacher was afraid of allowing the technician in assisting the students on experiment procedural issues.

Asked about the skills that are important for a student to pass examination, this is what one student who participated in group 3 had to say:

*Aa maybe..., I think the ability to use the instruments that are provided is also necessary. If you cannot identify the use of an instrument or what it is supposed to measure then it becomes a problem, so I think the proper use of instruments is a necessary skill in practical work.*

The students realised the need for good manipulative and measuring skills in order to come up with accurate experimental results that will assist one in passing practical work examination. Students in group 3 emphasised the need to avoid errors like the zero and parallax errors. This is what one member of group 3 had to say:

*We must first check on errors, like the zero error as well as avoid the parallax error when taking readings. I think this is very important during practical work session.*

Students in group 3 put more emphasis on good manipulative, designing and planning skills as being very important for one to pass practical examination as compared to presentation and analysis skills. The argument by group 3 members was that more often than not, one is bound to have good presentation and analysis skills if he or she had mastered manipulative and planning skills. The students in group 3 however hinted on the need to be fast when doing the practical in order to have enough time to do the write up as they were quite aware of the fact that marks were scored from the report and not from the experimental procedure.

Students in group 3 also mentioned the importance of good presentation and analytical skills in order to pass practical work examination. This is what one student had to say:

*It is important to have a neat table of results with correctly labelled column headings and values that are consistent in terms of significant figures or decimal places. It is also necessary to draw a good graph with a title and labelled axes as well as a neat and accurate line of best fit. Of course one needs to do the correct calculations from the graph by taking appropriate readings to calculate the gradient and the intercept.*

The students were quite aware of the marking points that are used by Zimsec when marking their final examination hence the reason for emphasizing these areas when writing a practical work report. Students in group 3 stated that they also get assistance from the teacher during practical work sessions if they face procedural challenges. The students also said that their teacher did not subtract marks from the practical work report for assistance rendered during practical work sessions despite the fact that it was the practice with Zimsec final practical work examinations. The reason for not subtracting marks during weekly practical sessions was to encourage the students to ask in areas where they were facing problems in order to find solutions during the practice sessions. This is what one student had to say:

*Every Monday, we do our practicals, he makes sure that he corrects us in areas where we are wrong. He will be observing all the mistakes. We also do revision of the previously done practical where we are also corrected.*

From what the student is saying, the physics teacher is concerned with the correct experimental procedure hence the supervision of students during practical work sessions. Students noted however that the teacher simply supervised them and does prompt remedy than scoring them marks during practical work sessions. The students in group 3 also mentioned one important aspect of revising previously done practical work activity and correcting students where they would have made some mistakes. This practice was a complete departure from what the students in group 2 said as they complained that they did not revise the practicals and as such were not aware of areas where they were making some mistakes.

Basically students who participated in the three FGD pressed on the need to have a variety of practical work skills that included manipulation, planning, designing, presentation and analysis in order to pass examination. Students also noted that it was important to do practical work revision in order for them to improve on their practical work skills. The students also mentioned that their physics teachers supervised them during practical work sessions but did not assess them. Students also stated that it was not necessary for teachers to subtract marks if one asked for assistance during practical work session despite the fact that it was the normal practice during Zimsec final practical work examination. The argument by students who participated in the FGD was that the weekly practical work sessions were meant for practice in preparation of the final examination hence it was a learning

process. The students further argued that subtracting marks will de-motivate them and will also make it difficult to correct common errors as students will be afraid of losing marks. The overall impression was that students emphasised more on the mastery of presentation skills in order to pass examination since they were not assessed during practical work session.

### **6.3 Students' views on the relevance of practical work assessment method**

In order to get students' views on the relevance of practical work assessment method in developing practical work skills, students were asked about the advantages as well as disadvantages of both DAPS and IAPS. Students were also expected to comment on the way in which practical work is assessed in light of the loop holes of the current method of practical work assessment as well as the changes that they would like to see in order to improve on the assessment of various practical work skills mastered by 'A' level physics students. Students were also asked to comment on the possibility of passing practical work examination by only possessing good presentation and analysis skills without necessarily having mastered other crucial practical work skills like planning, manipulation, observation and measurement. Students' views are presented in sections 6.3.1 to 6.3.3

#### **6.3.1 School A: Group 1**

To start the ball rolling, students who participated in the FGD at school A were asked to comment on the advantages of the current method of practical work assessment based on the practical work report which is also referred to as IAPS in this study. Students had varied views on this aspect. One student has this to say:

*Er, I think the one which we are doing right now is ok. We write a report and it's marked. If you consider a case of the project, it might not be based on what the student think but on how the teacher thinks the project must be done. The current method assesses the students' skills without influence of the outside world.*

The student was actually against the idea of DAPS using an artefact produced by the student at the end of the two year course as the product produced by the student could lack originality due to the influence from the teacher, the environment and availability of resources among other factors. The argument by this student was that if students are assessed from the practical work report after writing a two and half hour practical examination, the result obtained was a true reflection of the student's capabilities unlike in the case of the project method. Opponents of this idea further argued that, it was possible for a student to produce a good project because of outside support but the student would be lacking basic practical work skills. This simply serves to show the complexities that are involved in the assessment of 'A' level physics practical work.

Another student who supported the current method of assessing practical work using practical work examinations where the student submit the practical work report for marking has this to say:

*I think the advantage of the current procedure is on reducing costs. It is a standardised way of assessing candidates because all candidates are given the same instructions and steps on how to set up the apparatus and the kind of graph you need to draw.*

The student is bringing in two important issues on the advantage of assessing practical work using IAPS in that it is cost effective and objective unlike DAPS or the use of the project method where it is difficult to standardise the assessment procedure. The student argued that it will be easier to objectively score and grade the candidate as students will be following the same instructions at all exam centres as compared to the variations that are associated with the project method or DAPS.

The other student who participated in the focus group discussion in group 1 supported the current method of practical work assessment, pointing out that it helps to improve the students' presentation skills as well as sharpening the candidates' data analysis skills. This is what the student had to say:

*I think the advantage is that, it helps you to become a better evaluator and a good analyst of data which will help one when he goes in the world outside the school. You will be able to interpret any data that is given to you and use it to change the world.*

The student is emphasising the significance of data presentation and analysis skills as important aspects of practical work skills that must be possessed by an 'A' level physics student before going into environments beyond the 'A' level physics laboratory.

The students who participated in the focus group discussion also noted quite a number of disadvantages associated with the assessment of practical work using practical work reports as they summarily noted that the method only assesses a limited number of practical work skills which are mainly presentation and analysis skills. The assessment of practical work using practical work reports forced students to only concentrate on the mastering of those skills that will enable them to pass the examination from the sentiments echoed by 'A' level physics students who participated at School A in Group 1. This is what one student had to say:

*I also think you have just to be careful on your presentation because definitely the examiners won't be there when you will be doing the practical. They don't know how you did it anyhow. They just concentrate with the readings and the presentation and so you must be able to present your work nicely.*

The student is simply pointing on that IAPS results in the assessment of limited skills as compared to DAPS where a number of practical work skills can be assessed. The students who participated in the FGD at school A also pointed out that, it was possible to pass practical work examination because of

good presentation and analysis skills without necessarily having mastered various practical work skills expected of an ‘A’ level physics student who had undergone the two year course as outlined in the syllabus.

*I think it's very possible to pass.. yaa...the practical, because the other marks are awarded for the correct decimal places and significant figures. So I think you need to be very careful on the significant figures and decimal places and the units. If you have made a mistake during the practical then you score all the other marks awarded for significant figures and decimal places, so you can pass. I think it's possible because in physics they don't actually look at the accuracy of data on the table. On the graph they look at number of plots, the gradient and stuff so you can pass.*

As also revealed by the physics teachers who participated in the interview, students who participated during the FGD in group 1 also noted that it was possible to pass practical work examination by possessing good presentation and analysis skills without necessarily having mastered various practical work skills. Using this method of assessing practical work from practical work reports, the students who participated in the FGD noted that there was a high possibility of cheating to a pass mark. The students also noted that there was a chance of copying the next candidate during practical work examination. This is what one student had to say:

*I think these practical tests are meant to show individual abilities. So when I am in an examination let's take for example Zimsec and the question proves to be very challenging on how to set up the apparatus, I would be tempted, obviously to look at the colleague next to me and copy. I would be doing something that somebody else has already done not from my own thinking.*

The student is simply highlighting that the sitting arrangement of students during practical work examination where you can have up to twenty students writing practical work examination in the laboratory may result in cheating. Students pass not because they will be exhibiting the practical work skills but because of cheating. The students who participated in the FGD in group 1 also noted an important point on the aspect that, the practical work examinations that are written by students are mainly for academic purposes and not for teaching students real life skills that are needed in environments beyond the ‘A’ level physics laboratory. This is what one student in the group had to say:

*I don't think the methods of practical work assessment are quite efficient to prepare us for real life. You find in many cases, people who leave Zimbabwean schools and go for greener pastures or study at universities abroad have a problem when it comes to practical skills. This is because right now we are being taught about how to set up circuits and all that stuff but when you get there, it's more about how these things apply in life like coming up with models for example of cars ,aeroplane and so forth.*

*There is need to change from academic and theoretical practicals where we are required to prove a theory or equation to practicals that will assist us to solve societal problems.*

The way practical work is currently assessed does not encourage students to be innovative enough from the observations made by students in group 1. This is so because the students concentrate on mastering presentation and analysis skills in order to pass examination. The current method of practical work assessment is not all that relevant in equipping students with a variety of practical work skills according to students who participated in group 1.

The other noted disadvantage of assessing students from a practical work report was that students may fail not because they did not have good skills of manipulation, observation or designing but because of a poor practical work report. This is what one student had to say:

*If your presentation skills are terrible, even if you do the practical excellently, you might fail. This is because you might not know how to draw a proper table, present data on that table or draw an appropriate graph. Accurate results may be useless.*

The student is simply showing that one may fail practical work examination not because of failure to master skills like manipulation, observation, measurement or designing but because of poor time management and poor reporting skills.

The students who participated in FGD in group 1 managed to come up with a number of advantages of assessing students during practical work sessions to ensure that the students develop a variety of practical work skills in addition to presentation skills. This is what one student had to say:

*Direct assessment brings out the practical aspect of the examination. The examiner gets to actually see what you are doing. Are you doing the correct procedures? They don't consider mostly the written work but the practical side of it.*

The student is simply pointing out that through DAPS, a number of practical work skills can be assessed as opposed to IAPS. The student is therefore pointing out that DAPS is more relevant in ensuring that 'A' level physics students develop more practical work skills as opposed to IAPS. One student in group 1 also noted that some candidates are generally good with their hands but poor when it comes to report writing. The student considered a situation where one has good observation, manipulation, measurement and planning skills but may fail the practical examination because of poor presentation and analysis skills. This is what the student in group 1 had to say:

*There are some people who are good during practical sessions, who are able to do things like setting up apparatus well, take reading well but with poor presentation skills. At the end of the day they are just considering the presentation not the precision. That person will fail just because they are considering the presentation whilst his experiment was done exceptionally well.*

Then, judgement should be based on the skills exhibited during practical work session than the report submitted at the end of the practical work examination.

Another way which students who participated in group 1 said would be useful and relevant in ensuring that students develop and master a number of practical work skills was to assess students' practical work skills using the project method. According to participants, students could work on a project where at the end of the two year course, one will be expected to produce a model or an artefact together with a report to form the basis of assessment. The argument by proponents of this idea was that students could have mastered a number of practical work skills in order to come up with a good and useful model. This is what one student in group 1 had to say:

*Concerning projects, you get more time doing research where you master a variety of skills to produce a result. This is different from a practical work examination where you have just about 40 to 50 minutes to think of something especially on the design section. Not all of us are that flexible but the project is far much better.*

Students who participated in group 1 also managed to identify some disadvantages associated with the assessment of students' practical work skills using DAPS method. One student has this to say:

*When someone is looking over your shoulder when you are doing something, your confidence drops. Normally you will be scared of doing the wrong thing. You will be under a lot of pressure and you are likely to make mistakes and lose a lot of marks.*

The student was alluding to the fact that one tends to panic during DAPS especially if the assessment is done by an external examiner whom the students may not be familiar to. The students also pointed out the problem of subjectivity associated with DAPS as it will be very difficult to precisely score an observed skill, say on a scale of 0-10. The students in group 1 also pointed out that DAPS may involve high costs which schools will not be in a position to meet in addition to logistical challenges that are also associated with DAPS.

Students in group 1 noted that the current method of practical work assessment through practical work reports is not all that relevant in moulding a variety of practical work skills of 'A' level physics students. Students in group 1 however managed to come up with some advantages that are associated with IAPS.

### **6.3.2 School B: Group 2**

Some of the sentiments echoed by students who participated in group 2 at school B were similar to those noted in group 1. This section will however focus on those issues that were not raised by students who participated in group 1. Asked about the advantages of IAPS to show its relevance in developing practical work skills to 'A' level physics students, one student in group 2 has this to say:

*It's a cheap and objective way of assessing practical work. It only last for about two hours and you will be done unlike the project way where you spend almost two years doing it. Over that period you will be faced with some challenges that might be beyond your control like lack of resources or wrong advice from the supervisor.*

Students in group 2 managed to come up with a point that was not raised in the FGD with participants in group 1. Students in group 2 realised that the marking scheme that is used to mark the practical examination, the general form of which is clearly outlined in the 'A' level physics syllabus (9188) was so clear on areas where students could score marks. Students in group 2 therefore argued that because of that clear outline, the assessment of their practical work activities through the practical work report was likely to be fair and objective. Students in group 2 also said that, it was extremely difficult to be objective when assessing students during practical work sessions as the assessment was more likely to be affected by one's perception of the activities done by the candidate during practical work session than skills exhibited. In any case, the students in group 2 argued that it was difficult to accord a grade to an observed skill. Students who participated in group two also castigated the project method as a form of practical work assessment as it disadvantaged the candidate in one way or another. Some students in group 2 believed that through inference, it was possible to accurately assess students' practical work skills through practical work report. The students in group 2 believed that, to some extent, the assessment of students' practical work skills through practical work report was relevant in developing practical work skills of 'A' level physics students.

The majority of the students who participated in group 2 however noted more disadvantages on the development of a variety of practical work skills when students are assessed through practical work reports. One student had this to say:

*Aaa, I think the method used by Zimsec is unfair because, for example if you manage to do your practical very well but because of poor time management, you don't have enough to do the write up you panic and the end result will be that you fail after failing to complete the write up. What I think is the best method is that, Zimsec send a project question where you have a lot of time to work on it and then send it back to Zimsec for marking.*

The student was simply stating that one can fail the practical work examination because of failure to complete the practical work report due to lack of time to do so. The students may have mastered a variety of practical work skills but because of poor time management may fail to write the practical work report which is actually used as the basis of assessment. Students in general noted that the time allocated by Zimsec to do the practical then write a practical work report was too short. Because of such a weakness, students in group 2 consider the current method as being irrelevant in assessing the practical skills exhibited by 'A' level physics students.

Students in group 2 generally considered DAPS as a method of assessing practical work skills that will promote the assessment of a variety of practical work skills as well as a mastery of these skills. One student in group 2 had this to say about DAPS:

*It's a fair way of assessing one's practical work capabilities. They get an opportunity to see how we perform during practical work session as opposed to marking of a practical work report where the assessment is based on a theoretical report than practical aspects.*

The students in group 2 are arguing that the judgement must be based on practical work activities as observed during practical work session than relying on the report. Students in group 2 suggested that the assessment of the practical work skills during practical work sessions need to be done by internal examiners at the school as bringing in external examiners will result in the candidates panicking during examination. Part of group 2 members however argued that for it to be fair, there was need for an external assessor.

### **6.3.3 School C: Group 3**

Most of the sentiments of students in group 3 on the relevance of the current method of practical work assessment in developing practical work skills were echoed by those students who participated in group 1 and group 2. This section therefore will concentrate on issues that were not previously discussed. Students in group 3 considered the current method of practical work as not doing much in inculcating practical work skills of 'A' level physics students. It was important however that the students managed to identify some advantages of the current method of practical work assessment. One student in group 3 has this to say on the advantage of IAPS through practical work reports:

*Personally, I think it's the best way of assessing practical work because the syllabus is very clear on the marking points, so we know what to do when preparing for the final examination.*

The student in group 3 is not worried about developing various practical work skills during the two years of the 'A' level course but is only interested in the objectivity of the assessment method that will make it easy for one to pass examination as the assessment objectives are clearly outlined in the 'A' level physics syllabus. Another concern raised by the students in group 3 on the improvements on the current method of practical work assessment was to increase the time of doing practical work from two and half hours to three and half hours. The students realised that from the weekly practical work activities they do under examination condition, it was difficult to complete all the activities hence the need to increase the time. The further argument was that with more time, it was possible to perfect their practical work skills. This is what one student in group 3 had to say:

*What I think is that more time must be added uuuh, during the practical assessment because there are some practicals where uumm the instruments you are given are difficult to mount and with too many*

*steps to follow. There will be a design question which needs something like 40 minutes and its time consuming so more time must be added for us to finish the exam because 2 hours and 30 minutes might appear to be very short.*

Students in group 3 were also able to note some disadvantages associated with the current method of practical work assessment. Students who participated in FGD in group 3 noted that there was a possibility of cheating from the practical work report. The argument by group 3 members was that, despite possessing basic practical work skills of designing, planning, observation and manipulation, it was possible for one to pass practical examination in a case where one's presentation and analysis skills are good. This was further made possible by the fact that the marking points of the report were clearly outlined from the practical work assessment objectives as stated in the 'A' level physics syllabus. This rendered the current method of practical work assessment as not all that relevant in assisting students to develop a variety of practical work skills. This is what one of the participants in group 3 had to say:

*The situation is tricky though it might be possible because you can actually score a high mark than a person who has done the correct procedure but poor presentation. Due to good presentation of your results and showing clearly where you are getting like the gradient and so forth, the teacher might actually see that you know what you are doing and actually award you marks that is according to the perception of the teacher or the marker.*

The student in group 3 is simply raising validity issues associated with the assessment of practical work from practical work reports where there is a possibility of cheating by candidates in order to score high marks. One student in group 3 suggested that, cameras or video recording were necessary during practical work sessions, to reduce the possibility of cases where a student performed poorly during practical sessions but still manage to produce a good practical work report. The video footage will then compliment the practical work report to determine the final grade obtained by a candidate in a practical work examination according to the sentiments echoed by students in group 3.

Students in group 3 also argued that, the practical work report measures how well one can present results and not how good a candidate was during practical work session. The argument here was that a grade obtained by the candidate from the practical work report does not reflect one's ability to do the practical work. Students in group 3 further argued that if one is assessed only from the practical work report, it was difficult to assess those skills needed in society for its technological development. This is what one student had to say:

*From my own perception the point of doing the practical is to make sure that someone can do something physically. The report of the exam is just to make someone come out with a grade not seeing how good that person can do the experiment. For you to do the practical it means that maybe*

*when you pursue a programme at university you have to do things for the society you have ever to design maybe new technology that can develop the society but then when it's just a report that goes for marking then the design technique is not measured. It's not measured how good you are at a thing but then it's just a matter of results how well you can present your work and not how well you can perform the experiment.*

The statement from the participant in group 3 is quite clear and to further qualify it might distort the intended meaning. Students realised a number of advantages in using DAPS where a variety of practical work skills could be assessed and that cheating by students was minimal if not impossible among others that were also noted by participants in group 1 and group 2.

Students in group 3 dismissed the idea of assessing practical work through the project method where towards the end of the course candidates would be expected to produce an artefact. They argued that this required a lot of time that could affect the mastery of theory and time to do other 'A' level subjects.

As a way of concluding this section on the relevance of the current practical work assessment method employed by Zimsec to assess students' practical work skills, it was quite clear from the sentiments of the students who participated that it assessed a limited number of practical work skills. This resulted in the students mastering those practical work skills that would enable them to pass practical work examination at the expense of developing a variety of practical work skills necessary to change society.

#### **6.4 Students' views on possible alternatives to current physics practical work assessment method**

This section presents the views of the students who participated in focus groups 1, 2 and 3 at schools A, B and C respectively on possible alternatives to practical work examinations. Students who participated in group 1 noted that one way of assessing practical work was through the provision of themes to schools on the current problems society will be facing that require physics solutions and students develop models that forms the basis of assessment. Through this system, students in group 1 argued that solutions to societal problems could be found. The current way in which practical work is assessed does not provide the basis for this from the arguments raised by participants in focus group 1. This is what one student in group 1 had to say on this issue:

*It will better if we are asked to do models in order to solve the problems we are facing now. These are the same problems that we need to solve when we get to university level and beyond, where we start working as engineers or medical doctors.*

This seems to be a good idea which however will require government support as schools alone may not have enough resources required for the success of such projects. The government support will be required to bridge the social and economic gap among different schools in Zimbabwe so that the artefacts produced will not be affected with such disparities.

One student in group 1 suggested an idea of using two forms of practical work assessment namely, the current IAPS where assessment is based on the submitted practical work report and the use of the project method which should be done over a period of two years. The fusion method will benefit from the advantages of DAPS and IAPS. This is what the student had to say:

*I think it will better if we split practical activities into two. One that is done through practical examination like in the current scenario and the other which is done through the project method during the course of a year or two.*

This suggestion of having two forms of practical work assessment is based on the understanding that, through this model a variety of practical work skills will be assessed by both internal and external examiners. This in a way will improve the credibility and validity of the assessment procedures. The IAPS will mainly be focusing on the ability by candidates to follow instructions in addition to presentation and analysis skills while the project will have its focus on design, manipulation, observation, measurement and planning among others.

Students who participated in group 2 suggested the need for coursework to contribute towards the final assessment of practical work than a once off practical examination. The argument by participants was that the weekly practical tests done over the two year course were equally important in determining the practical work skills of the ‘A’ level physics students and as such it was important to consider them for the final grade obtained by the student. Pressed about the percentage contribution, the participants after some deliberations agreed that 50% was fair enough where the other 50% would be coming from the final practical work examination administered using the current method of IAPS through practical work report. Students who participated in group 2 noted the many factors that may contribute to poor performance by students during practical work examination which include panicking, illness or malfunctioning equipment. A coursework mark will therefore ensure that the student will be judged according to ability over the period of two years than only on the basis of the final examination.

Some students in group 2 argued that DAPS during practical work examination was the best way of assessing practical skills. The suggestion was that Zimsec need to dispatch external examiners to schools who will assess students during practical work examination. The argument was that this will ensure the assessment of a variety of practical work skills than simply relying on practical work reports that assesses mainly presentation and analysis skills. The arguments from the students

appeared to be sound and valid though they did not consider other logistical hinges associated with this kind of assessment method which include but not only limited to resources and human capital as most of these examiners were likely to be serving teachers that were also needed at their stations. The element of training of these external examiners could not be overlooked as well as resources to move these examiners to the schools where these assessments could be carried out. Many assessors will also be required to directly assess the students to the ratio of say one assessor to two students. This will therefore need first world economies to implement such a system. Despite all these noted problems, DAPS remains one of the valid and credible way of assessing a variety of practical work skills.

Some students in group 3 suggested the fusion of both DAPS and IAPS at 50-50% level. The suggestion was that there was need for two practical work papers, one where DAPS will be employed and the other where IAPS will be used. Participants in group 3 suggested that the internal examiner would be responsible for DAPS whilst for the second paper, practical work reports would be sent to Zimsec for marking as is the current practice. This system of assessment will tap from the advantages associated with both DAPS and IAPS.

Some students in group 3 brought in a completely new suggestion where they advocated for the assessment of practical work skills in science starting at primary school level instead of the current scenario where it is done from form three at some schools and ‘A’ level at other schools. This is what one student had to say:

*In order to improve on our practical work skills, I think it is important to introduce practical work assessment component maybe at grade seven or form one. By the time one studies ‘A’ level physics they will be a great improvement in mastery of practical work skills. A good example is that our colleagues who were introduced to the practical paper at form three or four perform better in practical work as compared to some of us who did alternative to practical paper at form three and four.*

The idea of introducing practical work at lower levels of education maybe a solution to some of the problems faced by students in mastering practical work skills in physics at ‘A’ level. This could be done by categorizing the skills that students need to master at lower level and higher levels. At lower levels, low order skills like measurement; planning and observation will be emphasized whereas higher order skills like manipulation and designing will be introduced at higher levels. It is therefore imperative that if assessment of practical work skills start at primary schools, then by the time the student chooses to do ‘A’ level science would have mastered essential practical work skills. This practice is common in subjects like agriculture, metal work and building where practical work assessment during national examinations begins at form two levels. The main message from students’ suggestions on alternative method of practical work assessment was that no one method is the best

way of assessing practical work skills hence the need for an integrative approach as different methods complements each other than competing among the group.

## **6.5 Comment on students' views on the assessment of physics practical work**

This section presents the discussion on students' views on the assessment of 'A' level physics practical work both at school level and during the final examination from Zimsec. The perceptions are compared with what is in literature on this issue of practical work assessment so that gaps will be identified and where possible an attempt made to fill the research findings literature gap.

Some students who participated in the FGD noted that the responsibility of supervising students during practical work session was mainly given to the laboratory technicians by the physics teachers. In some cases these laboratory technicians lacked basic skills of properly assisting students during practical work sessions. There were some instances however where the students who participated during FGD noted that their physics teachers assisted and assessed them during practical sessions for the first two practicals in mechanics and electricity with regards to observational, measurement and manipulative skills. As a way of encouraging the students to develop these crucial skills, the assessment done during the practical session contributed to the final mark obtained after marking the practical work report. Buick (2010:13) emphasises that when assessing practical work, it is important to assess skills rather than knowledge.

Students who participated in the FGD said that they concentrated on the mastery of presentation and analysis skills as these skills were important for them to pass the final examination. The minority of the students who participated during the FGD argued that it was important to master skills such as measurement, manipulation, designing and observation so that one can come up with accurate results that will make the presentation and analysis much easier. The further argument was that if the experimental procedure is done accurately this will also boost the students' confidence as well as motivating them to come up with a good practical work report. By writing a good practical work report, the student was therefore assured of passing the practical work examination. Reiss, Abrahams and Sharpe (2012:9) emphasise that the assessment of practical work should focus on students' competencies in actually doing practical work rather than focusing primarily on assessing students' understanding of practical work. Despite this wonderful observation by Reiss, Abrahams and Sharpe (2012) based on research work; the majority of the students who participated in FGD noted that circumstances forced them to concentrate mainly on the mastery of presentation and analysis skills in order to pass examination.

Students who participated in FGD noted that their teachers first taught and assisted them to use basic and common equipment used in mechanics and electricity practical work activities before they

embark on any practical work activity. This was important as students would be aware of how to use the basic equipment when doing practical work.

Students also noted the importance of balancing time between doing practical work and writing the practical work report. They acknowledged that sometimes they fail practical work because of failure to find time to complete writing the practical work reports. The problem here is that students may have the skills to carry out the activities accurately but unfortunately marks are not scored basing on one's ability to do these activities. According to Kennedy and Bennett (2005) assessment of practical work in Physics has continuously been a problem. Mathews and McKenna (2005) stress that it is important to consider which skills students must acquire which are useful in real life. There is need for practical knowledge that is relevant to the needs of the country and beyond. Roberts and Gott (2004:20) observe that pupils must be engaged in the process that scientists use to construct and apply knowledge and consequently their assessment need also to be based on activities than a report written at the end of the practical work session. Dillon (2008:42) also notes that the other challenge that teachers face is the difficulty in assessing the impact of practical work on students. The literature serves to highlight some of the complexities associated with the assessment of physics practical work.

The second part of the study involved finding out students' views on the relevance of the current practical work assessment method used by Zimsec in developing a variety of practical work skills of 'A' level physics students. The students who advocated for IAPS through practical work report argued that the method was objective and that the assessment objectives as outlined in the syllabus were clear. The further argument by proponents of IAPS in the FGD with students was that, through IAPS the grade obtained by the student was a true reflection of the students' capabilities unlike for example the case of the project method where they maybe external factors that influence performance like teachers' assistance and disparities in resource availability. The students who participated in the FGD also realised that the current method of practical work assessment was cost effective. According to Reiss, Abrahams and Sharpe (2012), it is a more straightforward and objective way of assessing practical work. The overall observation by the students who supported the current method of practical work assessment was that it assisted them in sharpening their presentation and analysis skills.

The majority of the students who participated in the FGD noted more disadvantages than advantages associated with IAPS rendering it irrelevant in assisting students to develop a variety of practical work skills. Hoult (2002) observes the need by teachers to properly assess practical work so that students can develop skills such as observation, manipulation and designing. Students who participated in FGD noted that it was possible to pass practical work examination without necessarily having mastered most of the crucial practical work skills expected of an 'A' level physics graduate as outlined in the Zimsec 'A' level physics syllabus (9188).The argument here is that it is possible to cheat your way

into passing the practical work examination considering the current way in which practical work is assessed. Students who participated in the FGD were quite aware of the fact that very little marks comprising less than 20% of the total were allocated for accuracy as the majority of them were for presentation skills. This created the possibility of passing practical work without necessarily possessing the necessary practical work skills during practical work sessions. Students also noted that the current way in which practical work is assessed does not encourage students to be innovative. Assessment of practical work remains the weakest aspect of teaching and learning of science according to Race (2005).

Students also noted that there was limited time to do the write up resulting in students failing not because of lack of basic practical work skills but because of limited time to write the practical work report. Despite the fact that students need to balance their time for practical work activities against time for writing a practical work report, it seems the activities students are expected to carry out in two and half hours are too many such that more often than not students lack time to do the practical report. Against this background there is need therefore to increase the practical work examination period from two and half hours to about three hours.

Students who participated in FGD noted that there is need to assess practical work activities directly in addition to IAPS. From the suggestions of the students who participated in the FGD these could be done through having two practical work papers that is the current one on IAPS and the other one on DAPS. The major advantage of DAPS noted by students was its ability to assess a number of practical work skills. According to Hoe and Tiam (2010:1) Singapore embarked on a radical shift to School Based Assessment (SBA) breaking a long tradition of a once off summative practical examination of the Singapore-Cambridge General Certificate for the Advanced Level (GCE-A level). The rationale for that radical shift was that school based assessment offered the potential for formative and comprehensive assessment of experiment and investigative skills. This according to Hoe and Tiam (2010:1) was necessitated by the weaknesses of indirect assessment of practical work which included the tendency to concentrate on written product without due emphasis given to process of investigation. Nadji et al. (2003) argue that physics practical work in the United States of America must be assessed using the embedded assessment system following the work of the Berkley Evaluation and Assessment Research Centre (BEAR). According to this system, a holistic approach of assessment from lab based activities to practical write up was employed.

Students who participated in the FGD reasoned that DAPS was more relevant in ensuring that ‘A’ level physics students develop more practical work skills. Other students even suggested the need for a third practical work paper which was to be assessed using the project method. In all these three papers suggested by the students, the participants noted that, it was necessary to consider coursework

marks to contribute not less than 20% of the final practical work mark obtained by the candidate. This is the case in subjects like building, agriculture and woodwork according to a synopsis of the assessment objectives of Zimsec syllabi of woodwork (6035), building studies (7035), fashion and fabrics (6051) among many practical subjects. In Finland according to Lavonen and Laaksonen (2009:930), the final mark for practical work assessment in science is a product of formative assessment during the course and summative assessment at the end of it.

Despite a number of advantages associated with DAPS, students who participated in the FGD were quite aware of the disadvantages which included panicking especially in cases where external examiners were engaged to do the assessment, high costs in terms of resources and human capital and issues of standardisation among others. DAPS according to the participants during the FGD was generally subjective as it was difficult to accurately score an observed skill say on a scale of 0-10. Abrahams et al (2013:218) observe the need to take note of some issues surrounding direct assessment of practical work skills. To adopt this system, there are a number of considerations in particular the manageability for schools, the best monitoring and checking arrangements. According to Abrahams et al (2013:228), “teachers may be tempted to inflate the grades of their own students as stakes are too high to expect them to do this honestly”. Using DAPS, Stacey and Spielman (2014:15) observe that “some things of value are impossible to assess validly”.

Students who participated in the FGD also suggested that it was necessary to start assessing practical work in science at early stages of education than towards the end of secondary education. The argument is that if practical work assessment starts at primary school level say from grade five, by the time the student considers to do science at ‘A’ level, that student would have developed a variety of practical work skills.

The complexities of assessing students’ practical work skills from the views of the students who participated in the study are also mirrored in the literature that was reviewed. Attention to improve assessment practice can enhance learners’ achievement according to Grants (2011), Grants and Jenkins (2011), Gatsby (2012) and Reiss, Abrahams and Sharpe (2012).According to Mathews and Mckenna (2005), the matter of assessing practical work remains a key issue in science education.

## **CHAPTER SEVEN**

### **TOWARDS AN ALTERNATIVE MODEL OF PRACTICAL WORK ASSESSMENT**

#### **7.1 Introduction**

This chapter presents arguments on the need for an alternative model of assessing ‘A’ level physics practical work in Zimbabwe which may be adopted or adapted by Zimsec as informed from both literature and the research findings. The proposed model however will not only be useful to the Zimbabwean physics education alone but can assist in getting insights into the need to change the way in which practical work in physics at ‘A’ level is assessed elsewhere. The development of this multi varied model is based on the realisation of the importance of practical work in science education in general and its influence in physics education in particular. Science education is considered as a vital tool for development across the world according to Maringe (2005). Kerr (2007) advocates for a strong foundation for scientific and technological literacy as the responsibility of the national education system which in turn must be supported by a strong teaching force in science and technology. According to Ibidapo-Obe (2007), there is need for continuous curricula review in science education to match changes within other sectors.

This chapter is divided into five sections, which are:

7.1 - Introduction

7.2 - An overview of ‘A’ level physics practical work assessment.

7.3 - The proposed model of ‘A’ level physics practical work assessment.

7.4 - Justification of the model.

7.5 - Anticipated challenges and proposed solutions.

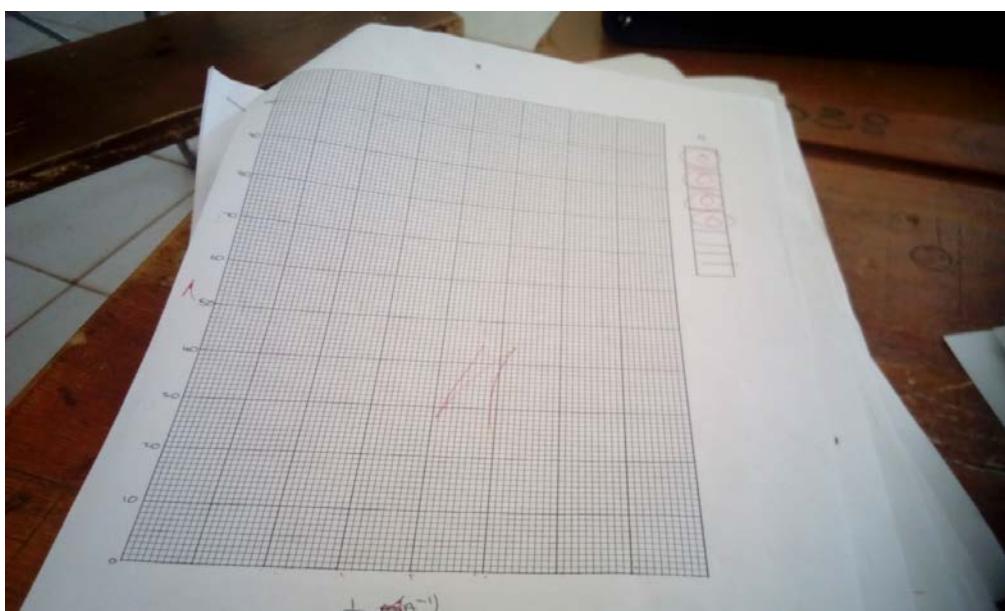
#### **7.2 An overview of ‘A’ level physics practical work assessment**

This section gives an overview on the findings, analysis, and discussion from the observations that were made during DAPS as guided by the observation schedule (see appendix 1) and the comments and grades obtained by the students from the practical work report. The second part of the section gives an overview of the discussion on students’ and teachers’ views on the assessment of ‘A’ level physics practical work. The rationale for this overview from the findings from qualitative and quantitative data as well as literature is to prepare the ground for the basis and justification for the need of an alternative model of practical work assessment. This proposed model will ensure that students develop a variety of practical work skills broadly categorised as manipulative, planning,

observation and design skills as opposed to the current scenario where students concentrate on presentation and analysis skills in order to pass practical work examination.

Observations made during DAPS show that the students basically failed to effectively manipulate standard laboratory equipment mainly because of failure to set up and effectively use apparatus relevant to the experiment. Observed students were generally slow in doing the experiment where systematic and random errors could easily be noted mainly because of poor manipulation of equipment and in rare cases instruments that were not working properly. Observations made during practical sessions show that students lacked innovation in dealing with novel experimental situations. The performance of students from DAPS was not as good as compared to IAPS. The majority of the students who struggled on DAPS managed to get better grades from the assessment of their reports to the extent that some of them who got a fail mark from DAPS managed to score more than 60% from IAPS. The reason could have been that students mastered presentation and analysis skills in order to pass examination without necessarily having basic skills of manipulation, planning, observation and designing.

The observed trend from the students' reports from the six experiments performed by the students was that students were generally good on results tabulation, performed fairly well on graphical work and were very poor on result analysis. This naturally made it easier for a student to pass from the assessment of their practical work reports as the analysis section contribute less than 20% of the total marks for the experiment. The major reason for failure from the assessment of the practical work reports was mainly due to failure to complete the write up especially on the section on graphical work which means that they could not do the analysis. Fig 7.1 and 7.2 show cases where the student failed to score a single mark on graphical work because of limited time to complete the write up.



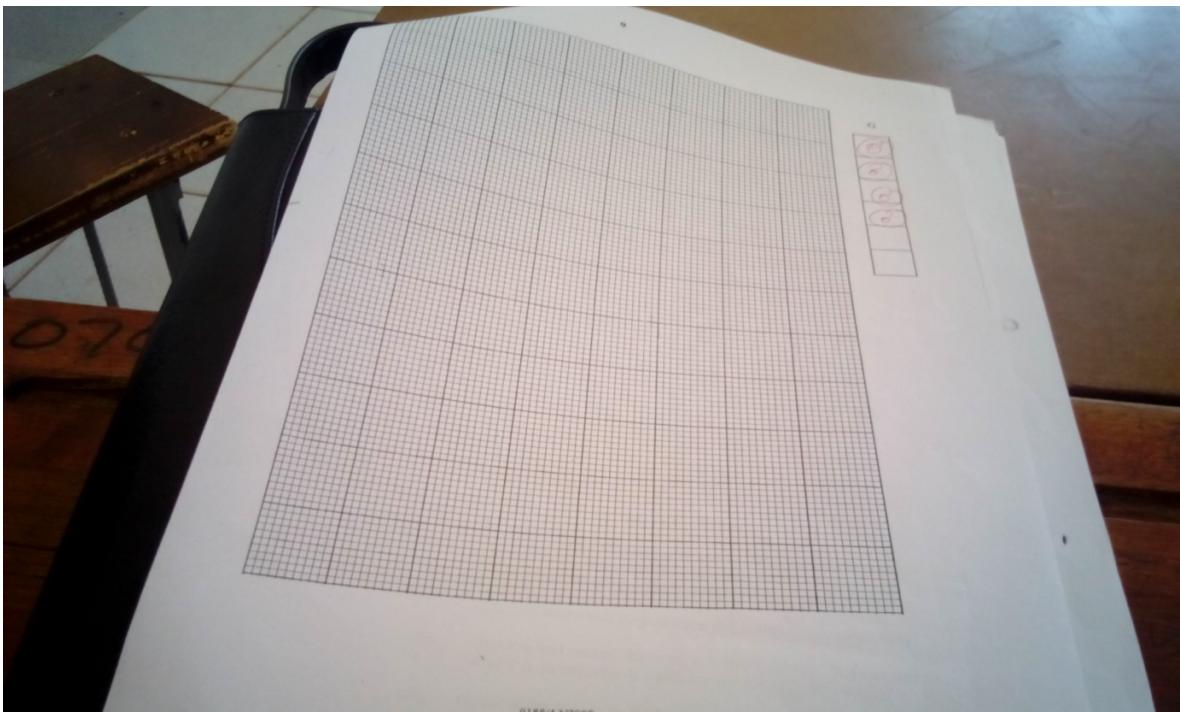


Fig 7.2 Graph sheet with a score of 0 Out of 5 which the student never attempted to draw a graph on because of limited time

Students who failed to do graph work because of limited time did not score any mark as indicated on the score column on the top right corner of the graph sheet in Fig 7.1 and 7.2. Failure to do the graph work also means that the students did not score any mark on result analysis. These students performed well during DAPS but failed the practical examination not because they did not have the practical work skills but due to the fact that they did not have enough time to complete the write up, scoring a chain of zeros on assessment points. Assessment of practical work in physics remains an issue in science education.

Statistical analysis of the results concurred with the observations through DAPS and IAPS. Pearson's correlation coefficient ( $r$ ) of percentage rating as observed by the researcher and the obtained mark from the submitted practical work report was calculated and found to be 0.135 with a P- value of 0.432. The correlation coefficient of 13.5% which was calculated in this case was found to be very small as compared to a threshold of 70% implying that there was no association between the grades obtained by the student from DAPS as compared to IAPS for the same practical work activity. The second conclusion that can be made from this scenario is that passing practical work through the assessment of practical work report does not necessarily mean that the student could have mastered the basic skills of manipulation, designing, observation and planning. A scatter diagram was also drawn to establish any correlation between the two sets of marks for the same experiment using two different methods of assessment. (See fig 4.1). The random scatter of points shows that there is no relationship between the scores obtained by students using DAPS as compared to IAPS.

Teachers' views on the validity of IAPS on the development of varied practical work skills of 'A' level physics were also sought. Physics teachers said that the weekly practical work activities which they administer to students were mainly assessed using IAPS in order to adequately prepare students for the final examination. Interviewed teachers noted that IAPS was necessary as it was objective and cheaper though it did little in assisting students to develop key practical work skills like measurement, observation, planning and designing. Physics teachers also noted that the practical work report does not give a true reflection of students' mastery of a variety of practical work skills. The physics teachers said that there was a possibility of cheating to a pass mark on the report as assessment objectives on practical work reports are clearly outlined in the 'A' level physics syllabus (9188). Students could easily meet the requirements of these objectives without necessarily having all the relevant practical work skills expected of an 'A' level physics student. The teachers however managed to note some of the disadvantages associated with DAPS despite the fact that it is useful in assessing many practical work skills. The disadvantages include high costs involved in the process, need for a large staff compliment to carry out the assessment, need for moderation and because of its subjective nature, abuse by teachers who may act unprofessionally among others. Despite these noted problems, the physics teachers who participated in the interviews felt that DAPS was more relevant in developing a variety of practical work skills of 'A' level physics students than IAPS.

The physics teachers however were of the general opinion that it was necessary to use both IAPS and DAPS when assessing students' practical work skills. Physics teachers also suggested the need to consider course work on the final practical work mark. The suggested percentage weighting of the course work mark was 40%. The teachers also advocated for the introduction of more practical work papers with a total contribution of 50% and theory papers contributing another 50% unlike the current scenario where practical work only contributes 20%.

Students' views were also sought on the relevance of IAPS on mastery of practical work skills. Some of the observations made by the students were similar to those made by the teachers. Students who participated during FGD said that they concentrated on the mastery of presentation and analysis skills as these skills were important to them to pass final examinations. It means therefore that the current method employed by Zimsec encourages students to master presentation and analysis skills in order to pass examination at the expense of other crucial skills like manipulation, planning, observation and designing. Students however acknowledged that IAPS was more objective as opposed to DAPS.

Students confessed that it was possible to cheat and pass practical work examination without necessarily having mastered crucial practical skills like manipulation, planning, observation and designing. The students argued that this could be achieved through correct tabulation of results as outlined in the assessment objectives, drawing an appropriate graph and analysing results correctly

despite the fact that the tabulated results could have been wrong. The students also noted that, more often than not, the practical activities they do were too many such that it was impossible to get adequate time to do the write up. The students suggested the need to increase the time of doing practical work activities. More importantly, the students also suggested the need to assess practical work from primary school level such that by the time students do ‘A’ level studies in science, they would have mastered a number of practical work skills.

There is evidence in literature for the need to shift in part or in full from IAPS to DAPS because of the problems associated with IAPS. According to Sentamu-Nambiru (2010:311) learner diversity requires the implementation of various assessment strategies as different learners may demonstrate the achievement of different outcomes in a variety of ways. Pedder (2006) argues for the need to assess students as they perform the tasks. Practical reports assessment according to arguments by Downs (2013:1) misrepresents the nature of science and poses risk in reducing the amount of practical work skills manifested by students.

There is danger of leaving students poorly equipped in skills required in progression routes in sciences if students’ practical work skills at ‘A’ level are only assessed through practical work reports. Reiss, Abrahams and Sharpe (2012:6) identifies two distinct ways of assessing practical work which are IAPS and DAPS. Reiss, Abrahams and Sharpe (2012:6) argue for the need to use both forms of assessment when assessing students’ practical work skills. Countries like Singapore, China, Ireland and United States of America shifted in part or in full from IAPS to DAPS according to Nadji et al. (2003), Mathews and McKenna (2005) and Hoe and Tiam (2010).

It is the assessment method that influences how practical work in science is taught and done as observed by Abrahams and Millar (2008), Abrahams and Saglam (2010) and Abrahams and Reiss (2012). Basing on the findings from the research study and reviewed literature, an alternative model of practical work assessment is therefore proposed. This model is illustrated in figure 7.3.

### **7.3 The proposed model of ‘A’ level physics practical work assessment**

The model proposes that practical work should contribute 50% of the total assessment of ‘A’ level physics subject with theory papers contributing another 50%. This is a departure from the current situation where practical work only contribute about 20% to the total assessment of an ‘A’ level physics curriculum.

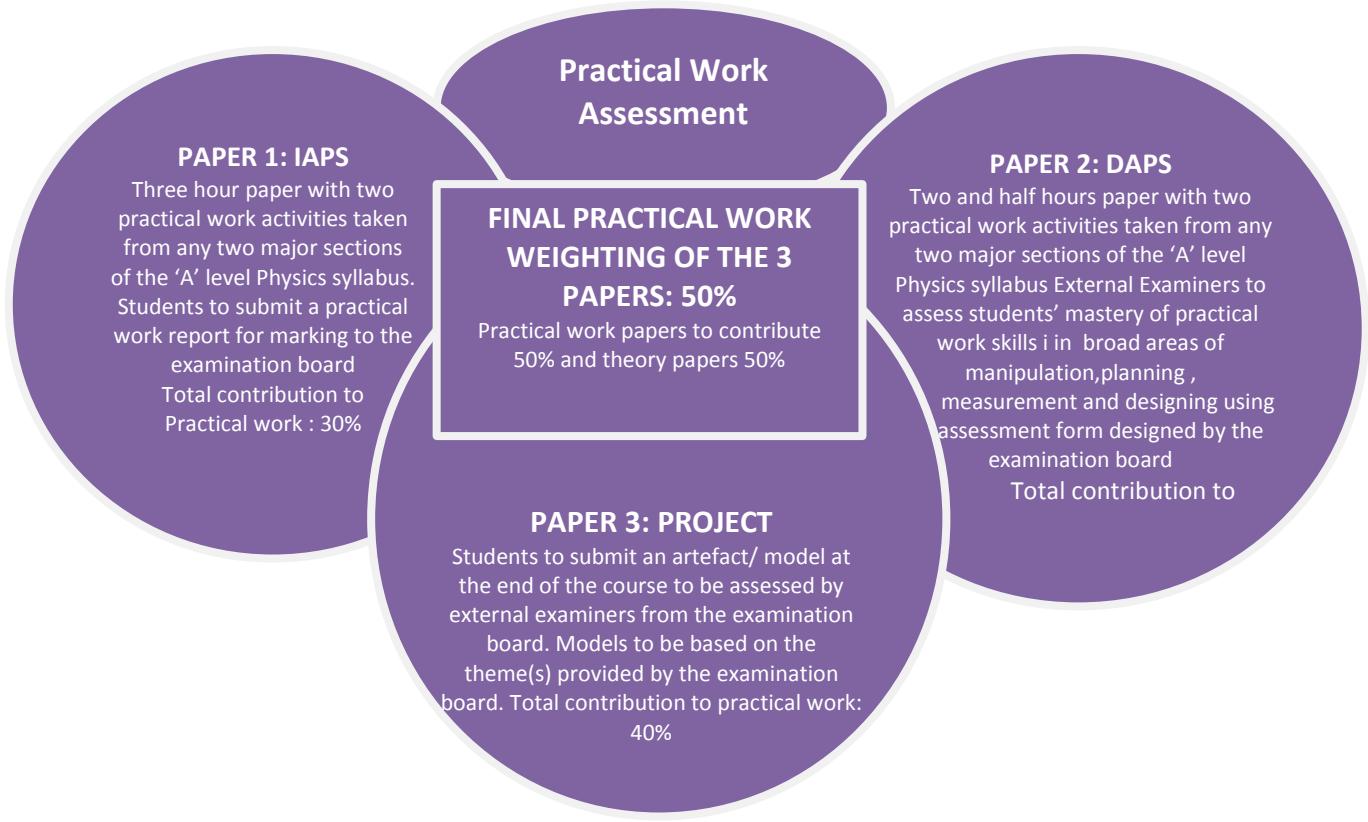


Fig 7.3: A Model of practical work assessment

Science is perceived to be contributing immensely to the economic and social well-being of any nation according to Zezekwa and Sunzuma (2013:11). It is believed that any country with sound science education system is likely to be more technologically developed as compared to that with poor science education base. According to Zezekwa, Mudau and Nkopodi (2013:318), school science constitutes the foundation for an efficient functioning in a technology and information driven society. It is against this background that for any advancement in technology there is need for more emphasis on the development of good practical work skills of 'A' level physics students. This is the reason for proposing in this model that practical work assessment should contribute 50% of the total assessment in an 'A' level physics curriculum. An increase from one to three practical work examination papers as shown in Fig 7.3 is therefore proposed by this model.

The traditional paper on IAPS through practical work reports need to be maintained because of the advantages already noted in literature as well as the findings of this study. The only change however which is proposed by this model is that there is need to increase the time allocated for the paper from the current two hours thirty minutes to three hours. The proposal to increase the time comes after the observations that were made during practical work sessions where the majority of the students who showed good practical work skill mastery during practical sessions failed practical work examination because of limited time to do the practical work report. The model also proposes that unlike the traditional way of taking the two practical work activities from the two

sections of the syllabus which are mechanics and electricity, other sections of the ‘A’ level physics syllabus need to be considered. The practical work paper should contribute 30% to the final practical work assessment mark. At the end of the practical work examination students are expected to submit a practical work report for marking by the examining board which in this case is Zimsec.

The model of practical work assessment proposes the introduction of a second paper which in this case is referred to as paper 2 (see fig 7.3). Unlike paper 1 which is on IAPS paper 2 will be on DAPS. The two papers will complement each other after realising the weaknesses and strengths associated with each form of assessment from literature (refer to table 2.1) and findings of the research study. The model proposes a two and half hours paper with two practical work activities taken from any two sections of the ‘A’ level physics syllabus. A panel of external examiners selected by the examining board will assess the students as they do practical work. The external examiners assess students’ practical work skills in the broad areas of manipulation, measurement, planning and designing using an assessment form designed by the examining board which in this case is Zimsec. The skills will be assessed on a scale range of 0-10. Moderation will be done through ensuring that each student will be assessed by two examiners as DAPS is often considered to be subjective considering the arguments by Abrahams, Reiss and Sharpe (2013), Downs (2013) and Stacey and Spielman (2014).

This kind of assessment is currently practised in the assessment of practical work skills in subjects like building studies syllabus code 7035, fashion and fabrics syllabus code 6051 and woodwork syllabus code 6035 among other practical subjects in Zimbabwe. The proposed weighting of paper 2 on DAPS is 30% of the final practical work mark. The idea here is that both papers 1 and 2 on IAPS and DAPS respectively must have the same weighting of 30% each. The two papers will ensure that quite a number of practical work skills are assessed, ranging from presentation, analysis, time management, manipulation, observation, planning and designing among others.

The third practical work paper proposed by this study is paper 3. This practical work paper is based on a project. The assessment of the student’s practical work skills is based on the production of model or an artefact where the student is expected to explain on the functionality of such an artefact. The production of this artefact is guided by theme(s) provided by the examination board which in this case is Zimsec. Physics students will be expected to work on this model over a period of about one year and produce the model six months before the end of the course. Teachers will be expected to assist their students to work on the proposed model during the course of their study. Just like in paper 2, a panel of examiners appointed by the examination board will then move from

one school to the other within a given district assessing students' models where students are expected to verbally explain on the functionality of their model in addition to providing a manual on how it works. The students will also be expected to respond satisfactorily to any questions that may be asked by the examiners about their model. Considering the Zimbabwean situation, an average of four schools per administrative district offer physics at 'A' level with an average number of eight students per school and as such it will be easy for the assessment to be carried out within a given district.

The rationale for the need to employ the project method is based on the fact that this kind of assessment will cater for the assessment of various practical work skills including those which are assessed using DAPS and IAPS. These additional skills that can be assessed using the project method include but not limited to research, innovation and improvisation skills. Stacey and Spielman (2014:19) argue that the project method has a great potential for developing a wide range of practical and inquiry skills of students. The concept of course work mark is also factored in as the project is done over a period of time where students get assistance from both their teachers and other stakeholders unlike paper 1 and paper 2 which are assessed under examination conditions.

#### **7.4 Justification of the model**

In coming up with this model of practical work assessment the following issues and concerns as raised by Stacey and Spielman (2014:40) were addressed:

- Is the method of assessment encouraging a wide range of physics practical work skills to be assessed considering the curriculum aims?
- Is the assessment valid and reliable? Does it test the right things and is this done accurately and consistently?
- The ability to withstand accountability pressures by avoiding unmanageable contradictions on teachers by acting as an assessor and judging themselves through the outcome of the assessment they make.

It is the argument of the researcher that by employing this comprehensive model of practical work assessment, this will assist in producing an 'A' level physics graduate who is more relevant at destinations beyond the 'A' level physics laboratory. It will also assist in the production of a graduate who can contribute to the technological development of the society after mastering different types of practical work skills during the 'A' level physics course.

This model proposes that the final practical work weighting contribute 50% to the final assessment in ‘A’ level physics where theory contributes another 50%. The current scenario considering the ‘A’ level physics syllabus (9188) offered by Zimsec is that practical work contribute 20% to the final assessment with theory papers contributing 80%. Physics is a practical subject and as such there is need for a balance between the assessments of practical work as compared to theory papers. This is in line with the new curriculum in Zimbabwe that basically emphasizes a shift from teaching our students’ academic aspects of the subject, to teaching them psycho-motor skills that are useful at destinations beyond the school environment. The government of Zimbabwe has since created Ministry of Psycho-motor Skills in addition to the Ministry of Primary and Secondary education after realising that the students who graduate from high school are full of theory and academic knowledge but lacked practical work skills to push the nation forward.

This can only be achieved if more emphasis is put on the assessment of practical work skills than the current scenario where the product produced after a two year ‘A’ level physics course is more of an academic than one who is practically skilled. It must be noted however that this cannot happen overnight, but requires the engagement of various stakeholders including the parents, teachers, government and the private sector as a mile’s journey begins with the first step.

## **7.5 Anticipated challenges and proposed solutions**

The major challenge anticipated from this model is on the mobilisation of adequate resources to smoothly implement it. These resources are both in terms of material as well as human capital. Viability and cost issues need to be considered as some of the external examiners are likely to be serving science teachers unlikely to be freed from their schools. They may also be concerns over logistical and modalities in terms both time and cost. These are some of the problems that are also currently faced when assessing practical work activities in subjects such as woodwork, metalwork and building studies among other subjects that are assessed using DAPS in Zimbabwe. It is important to involve other stakeholders like the private sector and other international organisations like the United Nations than mainly relying on the government and parents for funding. It is encouraging to note that in Zimbabwe UNICEF is currently funding those students who want to do science subjects like physics, chemistry, biology and mathematics at ‘A’ level through the Science, Technology, Engineering and Mathematics (STEM) initiative. The funding of STEM subjects in Zimbabwe starting 2016 after the realisation of limited number of students who do sciences at ‘A’ level mainly because of inadequate resources in schools to offer sciences in terms of human and capital resources.

Science is considered to be of importance to the economic and technological advancement of any country as already alluded to and as such it is worthwhile for any nation to invest in science education. About 70% of the universities in Zimbabwe have a mandate of training students in science and technology but these universities are failing to attract a threshold number of students to do the programmes in science currently because of the fact that a very small number of students do sciences at 'A' level as compared to other subjects. The proposed model must take advantage of this goodwill by UNICEF for its implementation as UNICEF is also funding for science school infrastructural development and activities that will facilitate an increase in the uptake of science subjects in schools at 'A' level.

The other area of concern especially on the assessment of students in papers 2 and 3 which are on DAPS and the project respectively is on the subjectivity associated with the assessment of the practical work skills of students. According to Abrahams et al. (2013:230), it is possible to determine whether a student has a given skill, but much harder to determine grade or level of performance. Corruption and un-professionalism - especially on the assessment of papers 2 on DAPS and 3 on the project maybe witnessed. Corrupt examiners could simply award high marks to some students as it is difficult to check on consistency when DAPS is employed unlike in IAPS where a practical work report is submitted as the basis of assessment. Because of this anticipated challenge, moderation and triangulation play an important role in ensuring that the assessment of students' practical work skills is valid and reliable. In this case both DAPS and IAPS assessment of practical work activities are employed to assess students' mastery of practical work skills as shown in fig 7.3. The moderation aspect is also considered as the assessment of the student's practical work skills for papers 2 and 3 is done by more than one person.

Another area of concern is on the discrete assessment of practical work skills especially in paper 2 on DAPS. Erickson and Meyer (2003) warn that discrete assessment of practical work activities might result in the loss of some important aspects where different skills interact with each other. This might be a problem in assessing physics students' practical work skills in paper 2. This problem however can be solved by the use of different forms of assessing students' practical work skills as proposed by this model (see Fig 7.3).

There is a possibility of cheating when IAPS is employed through the marking of practical work reports as is the case in paper 1. From the research findings of this study, the practical work report is not an accurate document to use to assess students' practical work skills through inference. It might be difficult to detect cheating when the assessment is done through the practical work report. IAPS also encourage rote and superficial learning. The weaknesses of this form of assessing

students' practical work skills can however be reduced considering the fact that the model proposes three forms of assessment that include IAPS, DAPS and the project method.

Another issue of concern is on manageability especially in paper 2 where DAPS is employed. It will be difficult for a single assessor to simultaneously assess each student. A single assessor may find it difficult to assess too many tasks, yet if the tasks are reduced the assessment will not be valid as observed by Stacey and Spielman (2014). The validity of this kind of assessment maybe improved through moderation where a student is assessed by more than one assessor. Considering the fact that there are very few students at a given school in Zimbabwe doing 'A' level physics, the issue of manageability may to some extent be managed.

According to Abrahams et al. (2013) and Stacey and Spielman (2014), teachers may be tempted to inflate grades of their own students in order to improve the pass rate. Because of such observations, the inclusion of coursework marks on the final practical work mark of the student was not considered in the proposed model of assessment.

Stacey and Spielman (2014:20) argue that the use of the project method as a form practical work assessment may result in significant design challenges in developing the model as well as awarding marks that are likely to produce results that are reliable and sufficiently comparable. This problem is catered for on the proposed model in fig 7.3 where the examination board is expected to provide theme(s) to schools on the nature and thrust of the project to be carried out by students to ensure uniformity. Students are also expected to produce a report or a manual on the functionality of the produced artefact which should also be considered during assessment.

Despite the proposal to increase the number of practical work papers from one to three to assess students' practical work skills using different forms of assessments, Reiss, Abrahams and Sharpe (2012:32) note that, it is clearly impossible to teach or assess a full range of practical skills that every employer and higher education institutions desire. There is no simple way to assess students' practical abilities reliably and validly. The matter of practical work assessment remains a key issue in physics education.

## CHAPTER EIGHT

### CONCLUSION AND RECOMMENDATIONS

#### 8.1. Introduction

This chapter is basically divided into two major sections. The first section looks at the summary of the study as well as conclusions drawn. The second part of the chapter addresses the recommendations made. Conclusions on the qualitative research paradigm were based on the notion that the problem of generalizability of research findings in qualitative research is solved through theoretical generalisation of findings as argued by De Vaus(2008), Gray(2011) and Neuman(2011). It is important however to revisit the research questions as a basis of the summary and conclusions drawn:

##### *Research question 1*

How do ‘A’- level physics teachers assess practical work skills of students during the course of their programme?

##### *Research question 2*

How relevant are the assessment practices on students’ practical skills development?

##### *Research question 3*

What are the possible alternatives to physics practical work examinations?

#### 8.2. Summary and conclusions

The research study was based on the assumption that, the way in which ‘A’ level physics practical work is assessed has an influence on type of practical work skills that are developed and mastered by students as also noted by Abrahams and Millar (2008), Abrahams and Saglam (2010) and Abrahams and Reiss (2012). The rationale for practical work according to Millar (2004:4) is to help students to understand how scientists work. According to Stacey and Spielman (2014:8), experiments are the essence of science and studying science without practical work is like studying literature without books. Practical work is therefore an important part of the physics curriculum and needs to be assessed in a way that will enable the students to develop a variety of practical work skills.

An analysis of the Zimsec ‘A’ level physics syllabus on the assessment of practical work showed that practical work which assessed through IAPS contribute about 20% of the total marks of an ‘A’ level physics curriculum. Downs (2013:1) however warns that practical work is a core skill in

science such that proposals which would allow pupils to fail their practical assessment and still achieve excellent grades in science are unacceptable. Further analysis of the Zimsec ‘A’ level physics syllabus(9188) on practical work assessment as highlighted on page 35 of the syllabus showed that students are awarded marks basically for correct tabulation of results, graphical work and analysis of results at the expense of skills such as planning, manipulation and observation among many others. The research study was therefore aimed at finding out whether the current way of practical work assessment will motivate students to develop a variety of practical work skills, crucial at destinations beyond the ‘A’ level physics laboratory apart from presentation and analysis skills that will enable the students to pass practical work examinations.

The research study was guided by the major research question: *How does practical work assessment method influence the development of practical work skills of ‘A’ -level physics students?*

Review of literature showed that, there are basically two ways of assessing practical work in science which are DAPS and IAPS as noted by Reiss, Abrahams and Sharpe (2012); Abrahams, Reiss and Sharpe (2013) and Stacey and Spielman (2014). These two ways of assessing students’ practical work skills involve different forms or models of assessment that include, use of practical portfolios, practical examinations, practical work coursework, open ended projects, artefacts or models and use of practical work inventory.

When assessing ‘A’ level physics practical work, most examination boards employ the IAPS as noted by Bennet and Kennedy (2005), Mathews and McKenna (2005), Treagust (2008) and Abrahams, Reiss and Sharpe (2013). The major reasons for employing the IAPS were basically on its objectivity and low costs involved in carrying out the activities though heavily compromising on issues of validity and reliability. The reasons cited in literature for not using DAPS by examination boards were to do with high costs involved, issues of manageability, requirements for training and a greater need for moderation because of its subjective nature. This was however against the background that more practical work skill could be assessed.

Observations by Abrahams, Reiss and Sharpe (2013:240) are that, China, Singapore, New Zealand and Finland often described as high performing countries all make use of a substantial proportion of direct assessment of their students’ practical science skills at some point in their schooling system. Review of literature also showed that it was beneficial to employ both IAPS and DAPS when assessing students’ practical work skills because there is no one best way of assessing

students' practical work skills validly and reliably as advocated by Nadji et al. (2003), Mathews and McKenna (2005) and Lunnetta et al. (2007).

A mixed method approach was used to collect, present and analyse data. In particular, the convergent-parallel mixed methods approach (Creswell, 2014) was employed in this case. According to Creswell (2014), the convergent-parallel mixed methods approach entails the collection and analysis of both quantitative and qualitative data which is then interpreted separately where comparisons may be done to establish any relationships of conformity or disconformity.

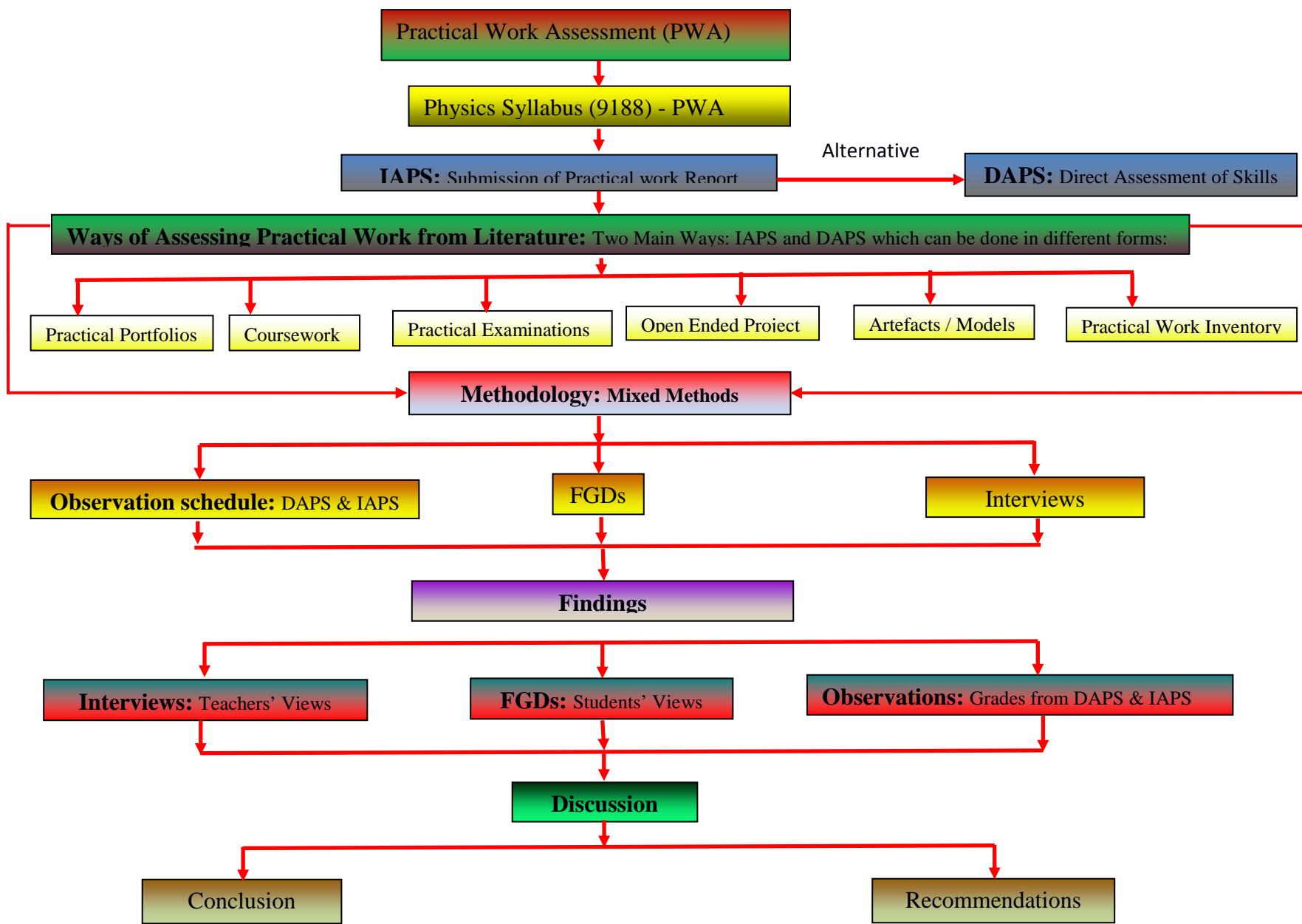


Fig. 8.1 Schematic Diagram of the Research Study

Quantitative data was collected using the structured observation schedule whereas qualitative data was obtained from interviews with the physics teachers and FGD with the ‘A’ level physics students. The discussion was based on the obtained results and appropriate conclusions were drawn and recommendations made. Fig 8.1 gives a summary of the study on the influence of practical work assessment method in developing practical work skills of ‘A’ level physics students.

The following conclusions were drawn from the study:

- Students performed better when assessed from the submitted practical work report than DAPS. Students mainly mastered presentation and analysis skills in order to pass examination suggesting that the practical work assessment method influence the practical work skills that are developed by students as also noted by Abrahams and Millar (2008), Abrahams and Saglam (2010), Abrahams and Reiss (2012) and Stacey and Spielman (2014). Students lacked basic skills of manipulation, observation, planning and designing to effectively plan an experimental procedure to come up with accurate results.
- The correlation coefficient ( $r=0.135$ ) was found to be very low implying that there was no association between marks obtained by students from DAPS as compared to those from IAPS. It can therefore be concluded that the practical work skills exhibited during practical work sessions cannot be inferred from the practical work report as currently claimed by Zimsec. This shows that the current method of practical work assessment employed by Zimsec to some extent is not valid and reliable.
- The disparities in results using different forms of assessment as well as views of physics teachers and students show that there is no simple way of assessing students’ practical abilities reliably and validly. This is also noted by Gopal and Stears (2007); Dillon (2008) and Stacey and Spielman (2004).
- From the views of both students and physics teachers, there is need to consider an integrative approach where different models of practical work assessment are combined. Abrahams and Millar (2008) refer to this kind of assessment as the embedded system. This idea of integration is supported by Erickson and Meyer (2003); Kennedy and Bennet (2005); Abrahams and Saglam (2010) and Reiss, Abrahams and Sharpe (2012).
- Teachers rarely assess students’ practical work skills during weekly practical work sessions in schools but mainly rely on the submitted practical work report from the observations made during practical work sessions as well as views of teachers and students who participated in the study.

- It is not possible to assess a wide range of practical work skills through IAPS from the views of teachers and students who participated in the study.
- Practical work is mainly assessed using IAPS because of lack of adequate time to employ other models of assessment, lack of resources and manpower according to the views of physics teachers and students who participated in the study.
- The current method of practical work assessment is not relevant in encouraging students to develop a variety of practical work skills of ‘A’ level physics students from the views of teachers and students who participated in the study.
- There is a possibility of cheating by students if IAPS is the only method used to assess students’ practical work skills. This according to the students and teachers who participated in the study could be very difficult to detect from the report.
- ‘A’ level physics teachers who participated in the study also noted that DAPS was too subjective to accurately assign students grades during practical work sessions and also that corrupt and unprofessional examiners could easily inflate marks.
- Teachers who participated in the study were of the view of incorporating coursework marks in addition to practical work examinations. The project method was to be considered as an alternative model of practical work assessment from the views of both teachers and students.
- From the observations made during practical work sessions, it was necessary to increase the time to do practical work as students in some instances failed practical work because of failure to get enough time to do the practical report despite exhibiting excellent skills during practical work session.
- ‘A’ level physics students who participated in the study were also of the view that practical work assessment in science should start at primary school level such that by the time students decide to do ‘A’ level physics practical work, they would have developed a variety of practical work skills needed at destinations beyond the ‘A’ level physics curriculum.

### **8.3. Recommendations**

The following recommendations need to be considered to achieve the desired improvement on the assessment of ‘A’ level physics practical work:

- The need to adapt or adopt the model of practical work assessment proposed by this study to assess ‘A’ level physics students’ practical work skills validly and reliably.
- The need to involve other stakeholders like the private sector and international organisations like UNICEF to improve on the teaching and learning of science by providing resources needed for science teaching in Zimbabwe. Involvement of other stakeholders should not only be for funding but also seeking ideas and advice on the practical work skills that are relevant at destinations beyond the ‘A’ level physics laboratory that may include tertiary institutions or apprenticeship in industry.
- To increase the time taken by students to do the practical work activities as observations during the study showed that students generally lacked enough time to do the practical work report.
- The need by Zimsec to introduce practical work assessment in science starting from primary school level than the current scenario where assessment of practical work in science starts at form three level.
- The need for further research in the field to come up with alternative models of practical work assessment.
- The need to consider models of assessment used in other technical subjects like woodwork, building studies, Food and Nutrition and Fashion and Fabrics in assessing science practical work.

Re-branding of the education system in general and physics education in particular becomes an important issue in Zimbabwe as innovation is necessitated by the desire to achieve the best. To this end, this achievement cannot only be entrusted to the board that is responsible for national examinations but it must be the responsibility of all stakeholders including industrialists, academics and the progressive society at large as a means of value addition to science education. Practical work is an important aspect of the ‘A’ level physics curriculum and therefore must be assessed in a way that will enable students to develop a variety of practical work skills.

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## **LIST OF APPENDICES**

### **APPENDIX 1**

#### **Structured Observation Schedule**

**Mastery of practical skills as observed by the researcher during practical session and the grade obtained from the submitted report.**

Skill	Comments and rating as observed by the researcher on score range 0-10	Obtained Mark from the submitted report by the student and comments of the teacher
A	Manipulative Area	
	A1 Manipulate effectively standard laboratory equipment	
	A2 Set up and use effectively the apparatus relevant to an experiment	
	A3 Work accurately, systematically and with reasonable speed	
	Score range(0-10)	
B	Observational	
	B1 Observe accurately.	
	B2 Record observations accurately.	
	B3 Read instruments correctly	
	Score range (0-10)	
C	Planning/Designing	
	C1 Plan an experimental procedure, applying standard laboratory techniques	
	C2 Modify established techniques to suit novel experimental	

	situations		
	Score range (0-10)		
	Percentage average score on skill mastery as observed by the researcher		Percentage average score from the submitted marked report

## **APPENDIX 2**

### **Interview schedule for Advanced Level Physics Teachers**

#### **Interview Questions:**

1. For how long have you been teaching advanced level physics?
2. What are your academic and professional qualifications?
3. Have you gone through the formal training of marking ‘A’- Level physics practical work done by the Zimbabwe Schools Examination Council (Zimsec)?
4. Which practical work skills do you assess students during practical work sessions?
5. What kind of assistance do you give to your students during practical tests?
6. What are the advantages of Indirect Assessment of Practical Work Skills (IAPS)?
7. What challenges do you face when assessing practical work using IAPS?
8. Where is the emphasis of practical work assessment from your own experience?
9. From your own opinion and experience do you think the practical work report gives a true reflection of the skills gained by the student during practical work sessions? Briefly comment on this issue.
10. From your own opinion and experience, do you think a student can pass practical work because of well-presented reports even though he/she has not done the practical activities correctly? Briefly comment on this issue.
11. What are the advantages and disadvantages of Direct Assessment of Practical Work Skills (DAPS)?
12. Which alternative model do you think will be useful in the assessment of ‘A’ –Level physics practical work?
13. What other comment do you have pertaining the assessment of advanced level physics practical work?

**Thank you very much for your time in responding to my questions**

## **APPENDIX 3**

### **Focus Group Discussion Questions for Advanced Level Physics Students**

1. Which practical work skills do you think are important for you to gain in order to pass practical work examination?
2. What kind of assistance do you get from your teacher during practical work session?
3. What is your comment on the way in which practical work is assessed?
4. From your own experience, do you think it is possible to pass practical work because of good presentation skills though you would have failed to do the correct procedures during practical session? Briefly comment on this issue.
5. What do you think are the advantages and disadvantages of Indirect Assessment of Practical Work Skills (IAPS)?
6. What do you think are the advantages and disadvantages of Direct Assessment of Practical Work Skills (DAPS)?
7. How best do you think practical work should be assessed by the Zimbabwe Schools Examination Council (Zimsec)?

**Thank you very much for taking your time to respond to my questions**

## **APPENDIX 4**

### **A letter to the Ministry of Primary and Secondary Education requesting permission to conduct research at schools in Harare and Mashonaland Provinces in Zimbabwe**

Department of Science and Mathematics Education  
Bindura University of Science Education  
P. Bag 1020  
Bindura  
Zimbabwe  
10 September 2014  
Email-  
Cell-0772115978

The Permanent Secretary  
Ministry of Primary and Secondary Education  
P.O. Box CY 121  
Causeway  
Harare  
Zimbabwe

**Reference:** Request for permission to conduct research in Harare and Mashonaland Central Provinces

**Title of Thesis:** The influence of practical work assessment method in developing practical work skills of Advanced Level Physics students in Zimbabwe.

My name is Nicholas Zezekwa, a DED Didactics student at the University of South Africa under the supervision of Professor Nkopodi Nkopodi the Head of Department of Science and Technology Education at UNISA.

The aim of the study is to get an insight of practical work skills that are developed by Advanced Level ('A' Level) physics students in Zimbabwe during their two year high school course before they enrol for tertiary education. The thrust is to find out whether the methods and practices that are employed by physics teachers as dictated by the Zimbabwe School Examination Council (Zimsec) 'A' Level Physics Syllabus on the assessment of practical work will assist the students in developing other crucial practical skills like manipulation, observational and designing apart from presentation skills. The study involves observation of physics students doing practical work, interviewing physics teachers and focus group discussions with students.

The study will be beneficial to the Ministry of Primary and Secondary Education as well as tertiary institutions and industry as it aims at proposing an alternative model of practical work assessment

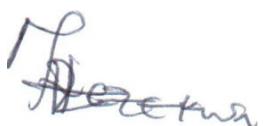
of Advanced Level physics students to enhance their psychomotor skills that are crucial at destinations beyond the high school physics laboratory.

There are no anticipated risks during the process of data gathering. The ministry will be furnished with the results of the research study upon completion.

I am looking forward for your response

Yours Faithfully

Nicholas Zezekwa

A handwritten signature in blue ink, appearing to read "Nicholas Zezekwa".

## **APPENDIX 5**

### **A letter to the secondary school heads in Harare and Mashonaland central provinces requesting permission to conduct research**

Department of science and mathematics education  
Bindura University of Science Education  
P. Bag 1020  
Bindura  
Zimbabwe  
10 September 2014  
Email-  
Cell-0772115978

**To:**

**School Head:**

-----.  
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-----.

**Reference:** Request for permission to conduct research at your school.

**Title of Thesis:** The influence of practical work assessment method in developing practical work skills of Advanced Level Physics students in Zimbabwe.

My name is Nicholas Zezekwa, a DED Didactics student at the University of South Africa under the supervision of Professor Nkopodi Nkopodi the Head of Department of Science and Technology Education at UNISA.

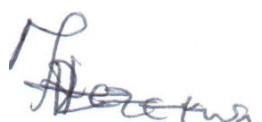
The aim of the study is to get an insight of practical work skills that are developed by Advanced Level ('A' Level) physics students in Zimbabwe during their two year high school course before they enrol for tertiary education. The thrust is to find out whether the methods and practices that are employed by physics teachers as dictated by the Zimbabwe School Examination Council (Zimsec) 'A' Level Physics Syllabus on the assessment of practical work will assist the students in developing other crucial practical skills like manipulation, observational and designing apart from presentation skills. The activities at the school will include overt observation of Advanced Level physics students doing practical work, interviewing Advanced level physics teachers on issues of practical work assessment and conducting focus group discussions with Advanced Level physics students.

The study will be beneficial to the Ministry of Primary and Secondary Education as well as tertiary institutions and industry as it aims at proposing an alternative model of practical work assessment of Advanced Level physics students to enhance their psychomotor skills that are crucial at destinations beyond the high school physics laboratory.

There are no anticipated risks during the process of data gathering. The ministry will be furnished with the results of the research study upon completion.

I am looking forward for your response.

Yours faithfully,



Nicholas Zezekwa.

## **APPENDIX 6**

### **An information-letter to the prospective participant**

Department of science and mathematics education  
Bindura University of Science Education  
P. Bag 1020  
Bindura, Zimbabwe  
10 September 2014.  
Email- nzezekwa04@yahoo.co.uk  
Cell-0772115978

**Title of Thesis:** The influence of practical work assessment method in developing practical work skills of Advanced Level Physics students in Zimbabwe.

#### **Dear Prospective Participant.**

My name is Nicholas Zezekwa and I am doing research under the supervision of Professor Nkopodi Nkopodi in the department of Science and Technology Education towards a DED didactics at the University of South Africa. We are inviting you to participate in the study entitled: *The influence of practical work assessment method in developing practical work skills of Advanced Level Physics students in Zimbabwe.*

The aim of the study is to get an insight of practical work skills that are developed by Advanced Level ('A' Level) physics students in Zimbabwe during their two year high school course before they enrol for tertiary education. The thrust is to find out whether the methods and practices that are employed by physics teachers as dictated by the Zimbabwe School Examination Council (Zimsec) 'A' Level Physics Syllabus on the assessment of practical work will assist the students in developing other crucial practical skills like manipulation, observational and designing apart from good reporting skills. The activities at the school will include overt observation of Advanced Level physics students doing practical work, interviewing Advanced level physics teachers on issues of practical work assessment and conducting focus group discussions with Advanced Level physics students.

Purposive sampling technique was employed to select three schools in the categories of former group A school, former group B school and a mission school. Convenient sampling was used to select each of the three schools in terms of easy access. The Advanced Level physics teachers and students have been selected in the study as they are considered to be the appropriate group to respond to the research questions. The study involves observation of physics students doing practical work, interviewing physics teachers and focus group discussions with students. Open

ended questions on how Advanced Level physics practical work skills of students are assessed by physics teachers, emphasis of Advanced Level physics practical work assessment and possible alternative models to physics practical examinations were asked. Each interview session is expected to last for about thirty minutes.

You are also reminded that the participation is voluntary and you are under no obligation to consent to participation. If you decide to take part, you will be asked to sign a written consent form. You are free to withdraw at any time and without giving reason but it will be impossible once the interviews have been conducted and practical work observations have been done. The potential benefits include professional development on part of the physics teacher in terms of practical work skills assessment as potential advantages and disadvantages of different methods of practical work skills assessment of students are exposed and alternative models proposed. There is no reasonably foreseeable risk of harm or side-effects to the potential participants except that the study will take some time that could have been used by the participant for other things.

Your name will not be recorded anywhere and no one will be able to connect you to the answers you give. Your answers will be given a fictitious code number or a pseudonym and you will be referred to in this way in the data, any publications, or other research reporting methods such as conference proceedings. Your answers may be reviewed by people responsible for making sure that research is done properly, including the transcriber, external coder, and members of the Research Ethics Committee. Otherwise, records that identify you will be available only to people working on the study, unless you give permission for other people to see the records.

While every effort will be made by the researcher to ensure that you will not be connected to the information that you share during the focus group, I cannot guarantee that other participants in the focus group will treat information confidentially. I shall, however, encourage all participants to do so. For this reason I advise you not to disclose personally sensitive information in the focus group.

Hard copies of your answers will be stored by the researcher for a period of five years in a locked cupboard at home for future research or academic purposes and electronic information will be stored on a password protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable. This study has received written approval from the Research Ethics Committee of the College of Education, UNISA. A copy of the approval letter can be obtained from the researcher if you so wish. If you would like to be informed of the final research findings, please contact Nicholas Zezekwa on 0772115978 or e-mail .

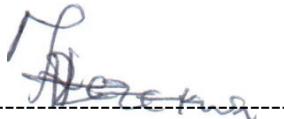
Should you have concerns about the way in which this research has been conducted, you may contact my supervisor Professor Nkopodi Nkopodi on +27124294731 or e-mail. Alternatively contact the Research Ethics Committee of the College of Education chairperson Dr Madaleen Claassens on.

Thank you for taking time to read this information sheet and for participating in this study.

Yours Faithfully

Nicholas Zezekwa

Signature-----

A handwritten signature in blue ink, appearing to read "Nicholas Zezekwa".

## **APPENDIX 7**

### **CONSENT TO PARTICIPATE IN THIS STUDY**

I, \_\_\_\_\_ confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read and understood the study as explained in the information sheet.

I have had sufficient opportunity to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time without penalty.

I am aware that the findings of this study will be anonymously processed into a research report, journal publications and/or conference proceedings.

I agree to the recording of the qualitative data from interviews and focus group discussions.

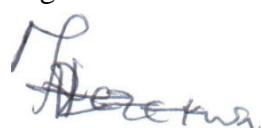
I have been assured that I will receive a signed copy of the informed consent agreement.

Name & Surname of participant

**Nicholas Zezekwa**

Name & Surname of researcher

Signature of researcher



Signature of participant

**Date-----**

**Date-----**

## **APPENDIX 8**

### **A LETTER REQUESTING PARENTAL CONSENT FOR PARTICIPATION OF MINORS IN RESEARCH PROJECT**

**Title of study:** The influence of practical work assessment method in developing practical work skills of Advanced Level Physics students in Zimbabwe

**Dear Parent.**

Your child is invited to participate in a study entitled: **The influence of practical work assessment method in developing practical work skills of Advanced Level Physics students in Zimbabwe.** I am undertaking this study as part of my doctoral research at the University of South Africa. The purpose of the study is to get an insight of practical work skills that are developed by Advanced Level ('A' Level) physics students in Zimbabwe during their two year high school course before they enrol for tertiary education and the possible benefits of the study are the improvement of practical work skills assessment at Advanced Level. I am asking permission to include your child in this study because ...he/she is doing Advanced level physics studies. I expect to have 18 other children participating in the study.

If you allow your child to participate, I shall request him/her to take part in a group interview for about thirty minutes and to observe her/him carrying out experimental activities

Any information that is obtained in connection with this study and can be identified with your child will remain confidential and will only be disclosed with your permission. His or her responses will not be linked to his or her name or your name or the school's name in any written or verbal report based on this study. Such a report will be used for research purposes only.

There are no foreseeable risks to your child by participating in the study. Your child will receive no direct benefit from participating in the study; however, the possible benefits to education are an improvement on the practical work skills that the students get before enrolling for tertiary education. Neither your child nor you will receive any type of payment for participating in this study.

Your child's participation in this study is voluntary. Your child may decline to participate or to withdraw from participation at any time. Withdrawal or refusal to participate will not affect him/her in any way. Similarly you can agree to allow your child to be in the study now and change your mind later without any penalty.

The study will take place during regular classroom activities with the prior approval of the school and your child's teacher. However, if you do not want your child to participate an alternative activity will be available.

In addition to your permission, your child must agree to participate in the study and you and your child will also be asked to sign the assent form which accompanies this letter. If your child does not wish to participate in the study, he or she will not be included and there will be no penalty. The information gathered from the study and your child's participation in the study will be stored securely on a password locked computer in my locked office for 5 years after the study. Thereafter, records will be erased.

If you have questions about this study please ask me or my study supervisor, Prof Nkopodi Nkopodi, Department of Science and Technology Education, College of Education, University of South Africa. My contact number is 0772115978 and my email is nzezekwa04@yahoo.co.uk. The email of my supervisor is nkpon@unisa.ac.za. Permission for the study has already been given by The Ministry of Primary and Secondary Education and the Ethics Committee of the College of Education, UNISA.

You are making a decision about allowing your child to participate in this study. Your signature below indicates you have read the information provided above and have decided to allow him or her to participate in the study. You may keep a copy of this letter.

Name of child

Name of parent/guardian (print)

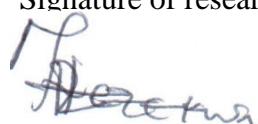
Signature of parent/guardian (print)

Date:

Name of researcher (print)

Signature of researcher (print)

**Nicholas Zezekwa**



Date:

10/09/2014

## **APPENDIX 9**

### **A LETTER REQUESTING ASSENT FROM LEARNERS IN A SECONDARY SCHOOL TO PARTICIPATE IN A RESEARCH PROJECT**

Title of study: **The influence of practical work assessment method in developing practical work skills of Advanced Level Physics students in Zimbabwe**

Dear Learner

I am doing a study entitled: **The influence of practical work assessment method in developing practical work skills of Advanced Level Physics students in Zimbabwe** as part of my studies at the University of South Africa. Your principal has given me permission to do this study in your school. I would like to invite you to be a very special part of my study. I am doing this study so that I can find ways that your teachers can use to results of the study to improve on the way in which they assess science practical work skills. This will help you and many other learners of your age in different schools.

This letter is to explain to you what I would like you to do. There may be some words you do not know in this letter. You may ask me or any other adult to explain any of these words that you do not know or understand. You may take a copy of this letter home to think about my invitation and talk to your parents about this before you decide if you want to be in this study.

I will be observing you doing practical work activities during the usual time you do ‘A’ –Level practical work to assess your practical work skills. Your name will not appear on the structured observation schedule and the assessment will not count for any marks at the school. I will not share any results with your teachers or parents. I am also inviting you to participate in a focus group discussion where questions on how Advanced Level physics practical work skills are assessed by physics teachers, emphasis of Advanced Level physics practical work assessment and possible alternative models to physics practical examinations will be asked.

I will write a report on the study but I will not use your name in the report or say anything that will let other people know who you are. You do not have to be part of this study, if you don’t want to take part. If you choose to be in the study, you may stop to take part at any time. You may tell me if you do not wish to answer any of my questions. No one will blame or criticise you. When I am finished with my study, I shall return to your school to give a short talk about some of the helpful and interesting things I found out in my study. I shall invite you to come and listen to my talk.

If you decide to be part of my study, you will be asked to sign the form on the next page. If you have any other questions about this study, you can talk to me or you can have your parent or another adult call me at: 0772115978. Do not sign the form until you have all your questions answered and understand what I would like you to do.

Researcher: Nicholas Zezekwa

Phone number: 0772115978

Do not sign this form if you have any questions. Ask your questions first and ensure that someone answers those questions.

### **WRITTEN CONSENT**

I have read this letter which asks me to be part of a study at my school. I have understood the information about the study and I know what I will be asked to do. I am willing to be in the study.

Learners name (print)

Learner's signature

Date:

Witness name (print)

Witness's signature

Date:

(The witness is over 18 years old and present when signed.)

Parent/guardian's name (print)

Parent/guardian's signature:

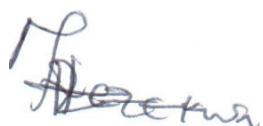
Date:

Researchers name (print)

Researcher's signature:

Date:

Nicholas Zezekwa



10 September 2014

## **APPENDIX 10**

### **A LETTER REQUESTING AN ADULT TO PARTICIPATE IN AN INTERVIEW**

#### **Dear Participant**

This letter is an invitation to consider participating in a study I am conducting as part of my research as a doctoral student entitled: **The influence of practical work assessment method in developing practical work skills of Advanced Level Physics students in Zimbabwe** at the University of South Africa. Permission for the study has been given by the Ministry of Primary and Secondary education and the Ethics Committee of the College of Education, UNISA. I have purposefully identified you as a possible participant because of your valuable experience and expertise as related to my research topic.

I would like to provide you with more information about this project and what your involvement would entail if you should agree to take part. The importance of practical work in school science and in education is substantial and well documented. The aim of the study is to get an insight of practical work skills that are developed by Advanced Level ('A' Level) physics students in Zimbabwe during their two year high school course before they enrol for tertiary education. The thrust is to find out whether the methods and practices that are employed by physics teachers as dictated by the Zimbabwe School Examination Council (Zimsec) 'A' Level Physics Syllabus on the assessment of practical work will assist the students in developing other crucial practical skills like manipulation, observational and designing apart from presentation skills. In this interview I would like to have your views and opinions on this topic. This information can be used to improve on the methods which are used to assess practical work.

Your participation in this study is voluntary. It will involve an interview of approximately *thirty* minutes in length to take place in a mutually agreed upon location at a time convenient to you. You may decline to answer any of the interview questions if you so wish. Further, you may decide to withdraw from this study at any time without any negative consequences.

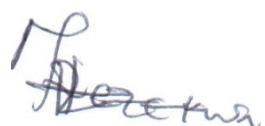
With your kind permission, the interview will be audio-recorded to facilitate collection of accurate information and later transcribed for analysis. Shortly after the transcription has been completed, I will send you a copy of the transcript to give you an opportunity to confirm the accuracy of our conversation and to add or clarify any points that you wish. All information you provide is considered completely confidential. Your name will not appear in any publication resulting from this study and any identifying information will be omitted from the report. However, with your permission, anonymous quotations may be used. Data collected during this study will be retained

on a password protected computer for twelve months in my locked office. There are no known or anticipated risks to you as a participant in this study. If you have any questions regarding this study, or would like additional information to assist you in reaching a decision about participation, please contact me on 0772115978 or email at nzezekwa04@yahoo.co.uk

I look forward to speaking with you very much and thank you in advance for your assistance in this project. If you accept my invitation to participate, I will request you to sign the consent form which follows below.

Yours sincerely

**Nicholas Zezekwa**

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## **APPENDIX 11**

### **CONSENT FORM**

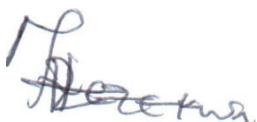
I have read the information presented in the information letter about the study ... in education. I have had the opportunity to ask any questions related to this study, to receive satisfactory answers to my questions, and any additional details I wanted. I am aware that I have the option of allowing my interview to be audio recorded to ensure an accurate recording of my responses. I am also aware that excerpts from the interview may be included in publications to come from this research, with the understanding that the quotations will be anonymous. I was informed that I may withdraw my consent at any time without penalty by advising the researcher. With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.

Participant Name (Please print)

Participant Signature:

Researcher Name: (Please print) **Nicholas Zezekwa**

Researcher Signature:



Date: 10 September 2014

## APPENDIX 12



### Research Ethics Clearance Certificate

This is to certify that the application for ethical clearance submitted by

**N Zezekwa [50860585]**

For a D Ed study entitled

**The influence of practical work assessment method in developing practical work skills of advanced level physics students in Zimbabwe**

has met the ethical requirements as specified by the University of South Africa College of Education Research Ethics Committee. This certificate is valid for two years from the date of issue.

A handwritten signature in black ink, appearing to read "Prof VI McKay".

Prof VI McKay  
Acting Executive Dean: CEDU

A handwritten signature in black ink, appearing to read "Mlaassens".

Dr M Claassens  
CEDU REC (Chairperson)  
[mcdtc@netactive.co.za](mailto:mcdtc@netactive.co.za)

Reference number: 2015 February /50860585/MC

18 February 2015

