The impact of practical tests in developing practical work skills to 'A' level physics students

N. Zezekwa
Department of Education, Bindura University Of Science Education, P. Bag 1020, Bindura.
nzezekwa04@yahoo.co.uk

Accepted 20 March 2006

Abstract

The practical work component is an important aspect of the 'A' level physics syllabus hence the need to carry out practical activities in a way which reflect the objectives of learning in the laboratory. Practical skills such as investigating, designing and equipment manipulation form an important base and link between Physics and Technology, paving way for some possible inventions by physicists from developing countries. This article aims to evaluate the impact of practical examinations on skills development of 'A' level physics students. Data was obtained through discussions, observations and two questionnaires that were administered to 96 'A' level physics students and 15 physics teachers from sampled Harare schools. The obtained data was analysed using frequency counts to determine the opinions of the majority. The major finding was that, students have difficulties in handling laboratory equipment, developing design and investigative skills because of the summative method employed by teachers when assessing practical work. The research also reveals that students are more concerned with mastering their presentation skills to pass examinations than equipping themselves with skills to tackle problems beyond the 'A' level physics laboratory. With the localization of 'A' level physics examinations in Zimbabwe, other forms of assessment need to be considered in the spirit of realizing the important link between physics and technology.

Keywords: Practical work, Technolgy, Assessment.

Introduction

The way in which practical work is assessed has a major bearing on the development of practical skills such as equipment manipulation, investigation and design. Students often are more concerned with the development of presentation skills that will enable them to pass examinations than the art and skill of carrying out practical work activities. For the purpose of this article, the focus will be on equipment manipulation, investigation and design skills as other key skills apart from presentation skills. The research was 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 despite them having passed 'A' level Physics Practical examination. The paper focuses on two main issues, which are:

- To evaluate the impact of current physics practical assessment method on skills development at 'A' level.
- To come up with suggestions on how best Physics Practical Work activities can be assessed to enhance development of other key skills such as manipulation, investigation and designing.

The paper thus strives to provide answers to the following questions:

- Can students develop adequate practical skills in physics considering the current assessment method?
- To what extent is the development of students' other practical skills compromised by the need to master the art of presenting practical test results?
- What are the possible alternatives to physics practical examinations?

In this paper practical work refers to tasks in which students observe or manipulate real objects or materials. The term technology, which is persistently used, refers to applying scientific knowledge to solve practical problems. On the other hand, assessment strives to check students' understanding and identify learning difficulties to improve on their performance. 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 based on the collected information.

Practical work is not only important for developing students' scientific knowledge as noted by Millar (1998) but must also help in the acquisition of key skills noted above. A relationship between practical

skills developed and the valued goals of science education as outlined in physics syllabus (9188) must be witnessed. From the general aims outlined in the Zimbabwe School Examination Council 'A' level physics syllabus (9188), the students are prepared for studies beyond 'A' level physics in engineering or in physics dependent vocational courses through developing attitudes relevant to science such as inventiveness. Some of the experimental skills expected as outlined in the syllabus are:

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

There must be a link between how practical work is done and how it is assessed. According to the requirements of the Zimbabwe School Examination Council (Zimsec) 'A' level Physics syllabus (9188); assessment of practical work is based on the submitted practical test report produced from a two and half hour examination. One is therefore forced to ask the question: How can the experimental skills as outlined in the syllabus be fully assessed on the basis of the submitted practical report? The most important purpose of practical work must be to develop skills for life long learning than to use practical work to verify a theory among many other less important issues. Presented with such a scenario, the link between the goals of practical work and the way in which they are assessed becomes a prerequisite area to revisit as far as assessment of 'A' level physics practical work is concerned.

According to Wellington (1994), confining assessment of practical work to practical examinations ended in the 1960s in the UK.The resulting practical examinations were assessed from written accounts of candidates, which could not give an accurate picture of their practical expertise. In the late 1960s, the first major change occurred through the curriculum development initiated by The Nuffield Foundation where the assessment of practical work skills by physics teachers in place of practical examinations over two years of advanced course was introduced. This enabled a wider range of skills to be assessed. Despite the realization of the shortfalls of practical examinations in the UK some five decades ago, it is alarming that the Zimsec syllabus still uses the same method, which was seen to be lacking on assessing observational, measurement and manipulative skills.

Some of the objectives for carrying out practical activities according to Denny (1985) are to develop and illustrate scientific approach to solve problems. It is not only the better performance we must quest for but there is need to have practicals that are compatible with society's expectations and aspirations. Physics as a discipline is very important for technological development. The ability to manipulate equipment and coming up with results will form the basis and prepare students for their societal roles. With the quest for economic revival in Zimbabwe and the need to develop home based technologies a review on the assessment method of physics practical work becomes a first step in a mile's journey. Self-reliance also implies the ability to manipulate the environment and the physics laboratory environment needs to be fully utilized in the development of these skills. The 'A' level physics practical course must facilitate the development of essential scientific and technological skills as foundation for future growth.

The assessment method of practical skills is quite different considering a developed country like the United States Of America where emphasis is put on skills development during the practical session resulting in their graduates giving a degree of technological leadership world wide, Treagust (2001). This must be an eye opener to physics educators in a developing country like Zimbabwe not withstanding differences in levels of technological advancement and resource availability. There is need for our high school laboratories to produce effective physicists so that they can apply their laboratory experience for the technological development of their country.

Review of literature

According to Tamir et al (1982), substantial attempts have been made in many countries to change the school laboratory from a place in which students perform "routine cookbook confirmatory exercise" to a place where students are engaged in investigations and solve problems so that they acquire inquiry skills. Tamir et al (1982) argue for comprehensive assessment of the skills associated with inquiry oriented laboratory work. In their Practical Test Assessment Inventory (PTAI) they argue that 10 % of the practical marks must be on manipulation as observed by the teacher during practical session.

Kempa (1986) comes up with the following assessment techniques to enhance manipulative skill development;

Table1: Analysis of manipulative skills (adopted from Kempa 1986)

Skill Competence	Performance Feature
Methodical Working	Correct sequencing of task. Effective and purposeful utilization of equipment. Effective use of working time. Ability to develop acceptable working procedures with limited instruction and resources
Working technique	Correct handling of tools, equipment and materials. Safe executions of working procedure and taking adequate precaution to ensure reliable observations and results.
Manual dexterity	Swift and confident manner of execution of practical tasks. Successful completion of an operation or part tasks.
Orderliness	Good utilization of available working space. Organisation in the placing of tools equipment and materials used and tidiness of working area.

This practical work assessment approach proposed by Kempa (1986) appears to be a more important approach to the development of key skills than the current way in which practicals are assessed in physics. The pressure for producing good examination results must not compromise skills development. Treagust (2001) criticizes practical assessment as a 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 develop skills. Practical working is learning by doing hence the need to assess the student skills in handling apparatus as in voltmeter reading, thermometer reading or designing a practical. Assessing reports of the work to a larger extent involve measuring the quality of the end product and not the work itself. Hoult (2002) hinted however that, assessment could be difficult because assessors may fail to agree on the assessment criteria and that students may be inhibited when someone is observing their performance. Hoult (2002) comes up with the following tips and questions concerning the assessment of 'A' level physics practical work;

- What exactly are the practical skills we wish to assess?
- Why do we need to measure practical skills?

Practical work is not just reaching a defined end point but is about processes and skills in doing it successfully. Hoult (2002) is pointing out the importance of practical work in physics education and the dilemma, which science educators may face when it comes to its assessment. The brainstorming questions are actually giving physics educators some insight into how best they can tackle the problem of assessing practical work. Students need to develop strategies for tackling a given investigation and the ability to design an experiment may reflect "a growing understanding of scientific inquiry", Millar (1998).

Reference was made in this section to the importance of formative assessment of practical work as alluded to by different authorities through their researches and observations, to develop students' key practical skills. This is thus a follow up study to assess the impact of summative assessment of practical work in the development of such skills in the Zimbabwe 'A' Level Physics Laboratory Environment.

Methodology

A total of ninety-six students from twelve selected Harare region high schools participated during the study. Purposive stratified sampling was used to select the schools where three former group A High schools, four schools from high density suburbs, three schools from the city center (two boys only and one girls only schools) and two private colleges registered with The Ministry Of Education Sports and Culture took part during the study.

The sample consisted of upper sixth students where an average of eight students participated from each school. The upper sixth students were preferred to the lower sixth since at the time of research, the subjects were at least half way through the 'A' level physics course and were expected to have done a number of physics practicals. Basically, three instruments were used in data collection. These include two questionnaires, an interview schedule and an observation schedule. The main instrument (the questionnaire) was developed in stages. After compiling some questions, the students' questionnaire was administered to thirteen students and the questionnaire for the physics teachers was administered to three teachers from randomly selected schools for pilot testing. The students and teachers were asked to comment on the questions especially on issues of ambiguity, clarity and length of the questionnaire. The questionnaires were then modified accordingly. The pilot study helped much in refining the questions. The interviews helped much in getting some in-depth responses and reactions or attitudes from students, thus they had a chance of

explaining and expressing their feelings about practical work assessment methods. These could not however be obtained from the questionnaires.

A general observation of the physics laboratory was done. The researcher had also a chance of observing students carrying out some practicals during practical sessions as well as going through some of the students' practical exercise books. This was an important way of checking the validity and reliability of the information given by subjects in the questionnaires. Data was analysed using frequency counts to determine the opinion of the majority.

Results and Discussion

The results for the teacher's responses are summarized in Table 2 while the responses for student's are given in Table 3. For each response column, frequency is at the top and the corresponding percentage at the bottom.

The results show a strong reliance by physics teachers on the submitted practical reports when assessing practical work activities. From Table 2, more than 65% of the teachers do not award marks for manipulative skills during the practical session but only rely on the submitted write up where accuracy is inferred from this report. On the other hand, 55.1 % of the student respondents acknowledge that, they need more practice and help from the physics teacher in practical skills such as setting up a circuit. The experienced teachers also noted that the present approach to assessment of practical work was not adequate as it deters the development of the key skills such as equipment manipulation, designing and investigation as more effort is put is on presentation skills (80 %). Of concern from the obtained results is the fact that the grade obtained by students in the final practical examination is not a true reflection of the pupils' abilities from the teachers' experience of teaching 'A' level physics (60 %). This realization concurs with the studies carried out in Britain where Wellington (1994) concluded that practical examinations do not give an accurate picture of the students' practical expertise. Students also complained of lack of guidance and help during practical sessions (25 %).

Observations made from students' marked practical exercise books indicated that those students with good presentation skills such as those outlined in the syllabus like taking repeated readings, taking note of a correct number of significant figures, presenting results in a single table with appropriate units, drawing a graph which cover at least half of the grid were scoring higher marks at the expense of mastering other key skills. Instead of awarding marks for skills such as observation, measurement and design even during weekly practical sessions the results show that teachers are only interested in the final submitted report without considering the processes (52.1 %)

If students are not guided when carrying out practical work activities, they are likely to make the same mistakes during practical sessions. Physics teachers are therefore encouraged to look at the source of the problem during practical session so that they will be in a position to link it to the practical write up. It is from this observation that the way practical work in physics is assessed has a great influence on skills development. Though the final examination is an assessment of a practical report from a two and half hour paper as outlined in the 'A' level physics syllabus (9188), it is quite important to help students develop key skills, be able to follow instructions and make accurate observations so that they will be able to come up with accurate reports. What happens during the practical session from the observations made, is that, instead of the teacher helping students to develop such skills, students are actually having a 'final examination' every time they are involved in practical work activities. Considerations must therefore be given to the way students perform a variety of tasks in a variety of settings and contexts. Skills, processes and procedures should be considered when planning for assessment. A checklist for assessing specific skill mastery is necessary during practical sessions. Competencies in design, measurement, data handling and interpretation should be an integral part of a comprehensive assessment. The practical skills must not only help the student to pass examinations but also need to go a long way to develop one's capacity for purposeful and autonomous action in a wider society.

The summative way in which practicals are assessed is not the best of methods if students are to develop the important skills. Formative assessment is necessary. There is need to revolutionize the way practical work in physics at 'A' level is assessed in Zimbabwe to match the assessment formats of practical work in disciplines such as woodwork, building and agriculture at 'O' level where assessment is done throughout the course, course work contributing to the final grade. Maybe the current way of assessing physics practical work was convenient during the time students were sitting for Cambridge examinations since it was not financially feasible to bring examiners from Britain to assess the skills during practical sessions or to send the designs than a practical test report to Cambridge for assessment. Now that it is the responsibility of Zimsec to assess 'A' level physics practical examinations, it is the researcher's recommendation that the formative assessment method as employed in the above mentioned subjects be adopted. Using this assessment format, students' work is assessed over a longer period giving students time to improve in skill

Table 2: Teachers ranked responses on their assessment of practical work. (N=15)

Question Number	Statement	Responses				
		1*	2	3	4	5
1	Marks are awarded for manipulative skills during practical sessions.	0 0%	4 26.7%	1 6.7%	8 53.3%	2 13.3%
2	The teacher marks practical reports that are done during the practical sessions	1 6.7%	1 6.7%	0 0%	7 46.7%	6 40%
3	Students are often assisted during practical sessions if they require help.	8 53.3%	5	2 13.3%	0 0%	0 0%
4	Marks are only awarded on the basis of the submitted practical report not considering the process of doing the practical	7 46.7%	5 33.3%	1 6.7%	1 6.7%	1 6.7%
5	The present approach to assessment of practical work is not adequate	3 20%	9 60%	1 6.7%	1 6.7%	1 6.7%
6	The grade obtained from pupils' work in the final practical examination is not a true representation of the pupils' abilities from your own experience	1 6.7%	8 53.3%	1 6.7%	5 33.3%	0 0%

*1= Strongly agree, 2=Agree, 3=Neutral, 4=Disagree, 5=Strongly disagree

Table 3: Students ranked responses on the assessment of practical work by their physics teacher. (N=96)

Question Number	Statement	Responses				
		1*	2	3	4	5
1	Marks are awarded for manipulative skills during practical sessions.	10 10.4%	10 10.4%	19 19.8%	26 27.1%	31 32.3%
2	The teacher marks practical reports that are done during the practical sessions	5 5.2%	7 7.3%	29 30.2%	29 30.2%	26 27.1%
3	Students are often assisted during practical sessions if they require help.	10 10.4%	14 14.6%	19 19.8%	24 25%	29 27.1%
4	Marks are only awarded on the basis of the submitted practical report not considering the process of doing the practical	7 7.3%	10 10.4%	26 27.1%	31 32.3%	22 22.9%
5	The present approach to assessment of practical work is not adequate	5 5.2%	12 12.5%	29 30.2%	24 25%	26 27.1%
6	The grade obtained from pupils' work in the final practical examination is not a true representation of the pupils' abilities from your own experience	38 39.6%	24 25%	19 19.8%	10 10.4%	5 5.2%

acquisition than simply relying on practical examinations. The continuous assessment of practical work has a number of advantages such as the elimination of 'chance failure' in a 'one off' situation and it enables a wider range of skills to be assessed, Wellington (1994). Woolnough (1991) rightly notes that, "... a barrier to change in the way practical work is assessed is the addition to summative practical examinations as part of science assessment".-

Lawrent (2001) also notes that, different assessment formats assess different competencies. He further asserts that recognition of the importance of assessment to contemporary educational reform has catalyzed research development and implementation of new methods of assessing practical work. In light of this observation, the assessment must closely match the types of understandings, skills and abilities that students are expected to learn. This summative assessment method fails to develop students technologically as they remain basically theoretical. It is sad to note that most of the students can rarely identify components like diodes, capacitors or transistors from a gadget like a television set whilst they can identify the symbols with ease from textbooks. The assessment should be formative and monitored from within the country where in some cases external examiners may be engaged. There is very limited evidence if at all to suggest that maximum use of physics skills learnt are made to benefit the society at large. Despite some associated problems related to honesty, resource availability and commitment, continuous assessment has a great potential of improving students' skills in practical work. There is therefore need to have a link between physics, industry and technology as way of applying physics to solve societal problems.

Conclusion

In this research, three main conclusions were made:
That it is quite difficult for students to develop practical skills if they are assessed through practical tests.
Students are more concerned with developing their presentation skills that will enable them to pass examinations than the art and skill of carrying out practical activities.
Continuous assessment can be a possible alternative to practical tests.

With the localization of examinations in Zimbabwe, there is need to revamp the way 'A' level physics practical work is assessed to enhance students' practical work skills as a base for technological development of the country. To solve this problem, a holistic approach is necessary. It must not be solely the work of individual scholars or a small collection of people who identify themselves as specialists in education. It must be the task of a broader community of scholars and practitioners who are committed to improving ways, in which we provide our students the opportunities to learn, develop key skills, be productive and develop Zimbabwe through science education.

References

Denny, M. 1985. Science practicals: What do pupils think? Science Education Journal.Vol. 8 No. 3, 325-336.

Hoult, D. 2002 Writing experimental reports. http.//.www.saburchill. com/phsics. 005htm.

Kempa, R. 1986 Assessment in science, London, Cambridge University Press.

Lawrent, F. 2001 Science achievement of various sub-groups on alternative assessment formats. European Journal Of Science Education Vol. 85 No. 2, 279 - 290

Millar, R. 1998. Students understanding of the procedures of scientific inquiry.University of York, UK.

Tamir P, Nussinovitz, R.and Friedler, Y. 1982. The design and use of practical tests assessment inventory. Journal of Biological Education Vol. 16 No. 1, 42 - 47.

Treagust, D.C. 2001 Using assessment as a guide in teaching for understanding: a case study of middle school science class learning about sound, Science Education Journal Vol. 85 No.2, 137 - 157.

Wellington, J. 1994. Secondary science; Contemporary Issues and practical approaches, London, Routledge

Woolnough, B.E. 1991. Practical Science, Bristol, Open University Press.

Zimbabwe School Examination Council (Zimsec) 'A' Level Physics Syllabus (9188) ,Zimsec, Harare.