

Characteristics of Practical Work in Science Classrooms in Namibia

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ABSTRACT *This paper presents a study into science practical work conducted in Namibian classrooms. Lesson plans, task sheets, student work, lesson transcripts and observation notes were used to identify intended learning outcomes. In addition, aspects of task design (inductive-deductive; open-closed; nature of student involvement) and the context of the practical task (duration; interaction patterns; types of task information and apparatus; nature of the student record) were explored. A profile form was used and its usefulness evaluated for the analysis of 12 practical tasks. The findings showed an emphasis on conceptual as opposed to procedural objectives, and a frequent change from an inductive to a deductive approach during the execution of the tasks. Pupil practical activity was rarely consolidated as a laboratory report but functioned as an enjoyable introduction to a set of general questions on the content covered in the practical. Suggestions are made for the modification of the profile form, and for in-service activities to support teachers to use practical work more effectively.*

Introduction

In recent years there has been an ongoing debate concerning the place of the scientific method in science teaching. The focus of most of such debates is the role of practical work. There is no great disagreement about the importance of practical work in school science. However, in both emerging and industrial societies, the great concern is its objectives—what students are to learn from their experiences in laboratory work and its effectiveness in developing what it aims to achieve (Kahn, 1990; Gott & Mashiter, 1991; Osborne, 1996; Bradley *et al.*, 1998). A clarification of the learning benefits of practical work is particularly important for developing countries, as large sums are being allocated for laboratory facilities (Walberg, 1991). Millar *et al.* (1999) claim that

practical work with real objects and materials does not only help learners to communicate information and ideas about the natural world, but it also provides opportunities to develop students' understanding of the scientific approach to enquiry (p. 33).

However, research by Hodson (1990) and others shows that practical work is often dull and teacher directed and highlights the point that students fail to relate their experiences to other aspects of their learning. He describes this notion very clearly as:

• **Domain C.** Experimental skills and investigations.

The curriculum change brought several problems. Most teachers were not trained for the new curriculum and inexperienced with practical work and its assessment. To deal with this, the Government of Namibia introduced various teacher upgrading programmes such as the Mathematics and Science Teachers Extension Project (MASTEP). This project aims to strengthen content and pedagogical knowledge and skills of teachers of senior science classes who have been trained to teach at junior secondary level only.

This study focused on the use of science practical work by such under-qualified teachers undergoing training through MASTEP. The findings will identify teacher needs to be addressed through in-service support, and form the baseline for measuring any impact of the MASTEP in-service programme in improving the effectiveness of the use of practical work in Namibian science classes. The aim of the study was to answer the following questions:

- (1) To what extent does Millar's profile form map essential aspects of practical work in Namibian classrooms?
- (2) What is the range of intended objectives for practical activities included in the scheme of work or lesson plans in Namibian secondary schools?
- (3) What are the design features of the practical tasks used?
- (4) What is the context within which practical work is integrated in science lessons?

Method

Data on science practical work carried out by 15 teachers in six schools, in town, peri-urban and rural areas, were collected. The teachers were asked to provide three forms of documentation for the practical lessons they had taught during the previous 6 months—copies of their lesson plan, student worksheets (where available) and a sample of student work. In addition to these written data, one out of three practical lessons was observed. Verbal classroom interactions between the teacher and the learners were recorded by audio-tape recorder placed at the front of the class. The tapes were transcribed verbatim. In addition, a non-participant observer used a pre-tested observation schedule to record the learners' questions and responses, the classroom arrangements and the use of any teaching aids.

Three of the authors independently used the profile form developed by Millar *et al.* (1999) to analyse the data for intended learning outcomes, the inductive or deductive nature of the task design, the context of the practical task and the characteristics of the task report. Where available, documentary data were considered together with transcripts and observational data for the same lesson in order to reconstruct classroom activities. Inter-researcher consistency of the coding was achieved for 72% of the codes during the first round of coding. Discussion of any discrepancies led to agreement on the allocation of an existing code within the profile form, or to amendments and refinements of the profile form. Frequency counts within the various code categories and across codes provided insight into common practice.

Findings

Sample of Practical Lessons

Four teachers (one quarter) failed to make any documents available, as they claimed not

syllabi, the intended outcomes of domain C '*Experimental skills and investigations*', require the students to:

- (1) use techniques, apparatus, and materials (including the following of a sequence of instructions where appropriate);
- (2) make and record observations and measurements;
- (3) interpret and evaluate experimental observations and data;
- (4) plan and carry out investigations, evaluate methods and suggest possible improvements (including the selection of techniques, apparatus and materials).

From the profile form, the intended procedural learning outcomes [(f)-(j)] are clearly described in the IGCSE syllabi. It is significant that outcome (k) ('to help students learn how to communicate the results of their work') is not included in the IGCSE syllabi.

Design Features of the Task

The profile form separates the design features of the task into two main categories. First, the scheme shows 11 options (B1·1a-k) of 'what students are supposed to do with the objects'. In the 12 lessons, these options are equally represented except that the observation of an event (B1·1j) is present in the vast majority of the tasks. Second, the scheme shows 13 options (B1·2a-m) of 'what students are intended to do with the ideas'. About half of the tasks require students to report observations (B1·2a) and account for observations in terms of a given explanation (B1·2k). Several tasks require students to identify patterns (B1·2b), explore relationships between objects (B1·2d), or test a prediction from a guess (B1·2h). Other options hardly feature: the students were not asked to 'invent' a new concept (B1·2f), test predictions from a law or theory (B1·2i/j), or account for observations by choosing between two rival hypotheses or by proposing an explanation themselves (B1·2l/m).

Frequently occurring combinations of what the students were expected to do with objects and ideas are reported below in some detail.

Half of the practical lessons can be summarised as 'observe this event (B1·1j), report your observations (B1·2a) and account for the observations in terms of a given explanation (B1·2k)'. An example is the task 'observe carefully a drop of ink placed at the bottom of a beaker filled with water, report what happens and explain your observation in terms of molecular movement'. In some cases the account was required in terms of a prediction (B1·2h), such as in the task 'observe the needle of the galvanometer when I'm moving the magnet in and out of a coil with more turns, record accurately what happens and compare this with your prediction of the needle's movement'.

A third of the practical lessons can be summarised as 'observe a quantity (B1·1a)/use a measuring instrument (B1·1k), explore the relationship between some physical quantities (B1·2d) and account for the observation in terms of a given explanation (B1·2k)'. An example would be a task such as 'after closing a glass tube with a pad of cotton wool with ammonia, measure the time it takes for the equally spaced pieces of red litmus paper to turn blue, make a graph and explain your findings in terms of molecular diffusion'.

A quarter of practical lessons can be summarised as 'use a standard laboratory procedure (B1·1b) and identify a pattern (B1·2b)', such as in 'given different tests identify which of the foodstuffs provided contain starch, fat and protein'. A similar proportion of lessons can be described as 'display or make an object/material (B1·1d/e/f) and identify a pattern (B1·2b)' such as in 'grow cress seeds in three boxes with no, one and two

The interaction pattern in practical science lessons was common for all tasks. Learners interact with peers within their large workgroups, and during the plenary discussions also with the teacher. Demonstrators and technicians are not part of the Namibian school environment. Thus, the item on learner interaction does not differentiate for any of the tasks. The way task information was provided was not always clear from the lesson plan or the student work. In a few cases, instructions were issued only orally, or the learners were referred to a textbook. However, in the majority of cases, written information was given, either as a hand-written worksheet, or, more frequently, as instructions on the board. In half of these cases, transcripts show that the teachers also elaborated the same instructions orally.

The types of apparatus (and materials) used during practical work are of interest. Three quarters of the tasks involved standard laboratory equipment and materials, and half of the tasks required everyday equipment or materials. The apparatus in the latter group was equally split between equipment/materials used for its everyday function (foodstuffs for food tests, and plastic bags for collecting litter), and those which constituted improvised laboratory equipment/materials, such as cardboard boxes and table dishes to grow cress seeds. Such improvised apparatus deserves a category *per se* amongst the classification of types of apparatus used for practical work.

Student Record of Work

It is very surprising that for more than half of the practical tasks no record of the procedures, data or conclusions of the practical work was made. The lesson plans do not indicate that the teachers expected the learners to produce such records. Seemingly the intention of practical work in these cases was the provision of a memorable experience. For half of these (unrecorded) tasks, the practical experiences provided the starting point for answering a number of application questions. These were often only remotely related to the experimental procedure followed or the data likely to be collected. For a quarter of the tasks, the learners filled out a worksheet. In one case they were asked to use the data to plot a graph (for the diffusion rate) and in another to make a calculation (for a density). If a record was kept, this was invariably to allow assessment of the learners' performance.

Discussion and Conclusions

Appropriateness of the Analysis Scheme for Practical Work in Namibian Classes

Although a larger study is required to provide a representative overview of the practical activities in Namibian science classes, this study validly tested the usefulness of the profile form to describe these activities. The data show that, on the whole, the scheme is suitable to map practical work in Namibian classrooms. There are, however, some areas which need adjustment. The options for the nature of student involvement (B1·5) and for the duration of the task (B2·1) need to be expanded in order to include the practice of teacher demonstrations to large sequential groups of students rather than plenary demonstrations. Equally, the options for the type of apparatus used (B2·4) need to be expanded to include improvised equipment (i.e. replacement of standard laboratory apparatus), as distinct from everyday equipment used for everyday purposes.

The analysis of the teachers' lesson plans *per se* appears to provide only a limited picture of what actually goes on in classes during practical lessons. Student work and

groups could be asked to do different activities and then the groups should rotate to complete all the arranged practical work. Thus, teachers should be encouraged to set up different activity stations for learners, and learners should be given a variety of practical problems to investigate.

The Context of Practical Work in Science Lessons

A quarter of the teachers in the sample did not provide practical work at all. The remainder offered few opportunities for student practical work. Practical lessons were being scheduled but did not represent 'full practical lessons', that is, where learners have hands-on experience. Also, several practical activities only provided an (enjoyable?) introduction to answering worksheet questions which were unrelated to the practical activity other than that they dealt with the same science concepts. In many cases, recording observations or measurements was seen as peripheral. Drawing conclusions or making generalisations from experimental results was done orally and in plenary sessions, if at all.

It is striking that for the majority of the practical activities, minimal written information was provided, and hardly any written reporting was required. This may well be related to the time requirements of laboratory reports or of filling in worksheets, particularly with English as a second language learners. However, teachers need to be helped to ensure that all necessary information for practicals is written down to avoid disrupting the flow of practical activities by constantly reminding students of what is to be done. Also, teachers may develop tasks where the science activity report reinforces the appropriate use of English, supporting learning in both subjects.

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Appendix

Practical work task

Profile form from Millar *et al.* (1999)

A Intended learning outcome (learning objective)

- (a) To help students identify objects and phenomena and become familiar with them
- (b) To help students learn a fact (or facts)
- (c) To help students learn a concept
- (d) To help students learn a relationship
- (e) To help students learn a theory/model
- (f) To help students learn how to use a standard laboratory instrument, or to set up and use a standard piece of apparatus
- (g) To help students learn how to carry out a standard procedure
- (h) To help students learn how to plan an investigation to address a specific question or problem
- (i) To help students learn how to process data
- (j) To help students learn how to use data to support a conclusion
- (k) To help students learn how to communicate the results of their work

B1.1 What students are intended to do with objects and observables

Use	an observation or measuring instrument	(a)
	a laboratory device or arrangement	(b)
	a laboratory procedure	(c)
Present or display	an object	(d)
Make	an object	(e)
	a material	(f)
Observe	an event occur	(g)
	an object	(h)
	a material	(i)
	an event	(j)
	a quantity	(k)

B1.2 What students are intended to do with ideas

Report observation(s)		(a)
Identify a pattern		(b)
Explore the	objects	(c)
	relationships between physical quantities (variables)	(d)
Invent (or 'discover')	objects and physical quantities	(e)
	a new concept (physical quantity, or entity)	(f)
Determine the value of a quantity which is not measured directly		(g)
Test a prediction	from a guess	(h)
	from a law	(i)
	from a theory (or model based on a theoretical framework)	(j)
	in terms of a given explanation	(k)
Account for observations	by choosing between two (or more) given explanations	(l)
	by proposing an explanation	(m)

B1.3 Object or ideas driven?

- (a) What the students are intended to do with ideas arises from what they are intended to do with objects.
- (b) What the students are intended to do with objects arises from what they are intended to do with ideas.
- (c) There is no clear relationship between what the students are intended to do with objects and with ideas.