UNIVERSITY OF VENDA

DEPARTMENT OF MATHEMATICS AND SCIENCE EDUCATION

An Investigation of the availability and use of learning materials in Grade 12 science classes in some selected schools in the Northern Province.

RESEARCH SPONSORED BY DANIDA AND MANAGED BY THE JOINT EDUCATION TRUST IN RESPECT OF PEI RESEARCH PROJECT

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EXECUTIVE SUMMARY

Background

1. Many claims are made about the effect of different resources on student performance. Recent research reports suggest that in the South African context, there is inadequate empirical information on how the provision and effective use or otherwise of resources and facilities - however defined - are most significant in affecting student learning outcomes in science. If the effectiveness of each resource were known, it would simply be a matter for policy makers to define an optimal set of resources and decide on what policies that would most likely produce high levels of student achievement.

2. The present study was an attempt to explore that relationship if any, one that focuses on the role of materials (school educational inputs) in pupil achievement (school outcomes). This preliminary investigation was intended to provide an insight into the ways in which the processes of teaching and learning science in grade 12 science classes are affected by the availability and quality of use of classroom support materials in the school. Through this understanding, it is hoped that the data provided will enable educational authorities to appreciate more the schools intrinsic deficiencies that inhibit academic performance in the Northern Province. The anticipated end product of this research is to make policy and reform decisions grounded in evidence rather than hunches.

Objectives

3. The objectives of this research project were:

! To identify representative schools in the Northern Province with grade 12 science classes
and select 10 schools with a range of performance pass rate (0-100%) in the matriculation physical science examination;

! To undertake a survey of resources/facilities and materials checklist, in the respective schools and grade 12 science classes, and provide a description and data through school and teacher profiles;

! To observe the process of teaching and learning in the grade 12 science classes in relation to the availability and use of classroom support materials;

! To infer the role of learning materials in student achievement in science.

Methodology

4. The study used a survey design, questionnaire and observation schedule instrument in a multi-stage and purposive stratified sampling design. The study's research methodology was qualitative, inductive and case study based. The population of study comprised all grade 12 science classes in the Northern Province. The sample schools were selected from the Thohoyandou District Area, one of the 31 District areas that make up the Northern Province in a 3-stage purposeful stratified sampling procedure. The area was a suitable choice because it had as wide a range of matriculation examination performance in science, and as wide a range of

quality in the physical conditions of its secondary schools as one is likely to find in any low-income District area in the Province. In drawing a representative sample of schools we considered the rural-urban divide, a range of school types based on matriculation examination performance in science and the highest-grade level. Altogether the ten sample schools represented high, medium and low (poorly) performing schools from urban, peri-urban, and rural areas with grade 12 science classes.

5. *Data collection* was carried out in two main phases. The first was an audit phase that involved baseline survey of resources and facilities available for the teaching and learning of science in the selected schools. Data on school and teacher profiles were obtained by a combination of site visits, self-completed questionnaires by grade 12 science teachers and headteachers as well as individual discussions and interview sessions with them.

The second phase consisted of classroom observations of grade 12 science lessons. This involved the use of a prepared schedule covering various aspects of classroom conditions, management, methods, use of materials, patterns of interactions and student behaviour. Three lessons of each grade 12-science teacher were observed. Analysis of data involved determining the effects of the availability, quality and use of materials on the processes of teaching and learning.

Summary of Major Findings

Resource Availability

6. In general, in all ten schools, the study found great variations in the resources and facilities available for the teaching and teaming of science at grade 12 level. Although all schools in the study with the exception of one were public schools, sitting for the same public examinations and dependent on the Provincial government for the bulk of their funding, the five poorly/ low performing schools were so impoverished, that some did not have the basic necessities such as sufficient desks per class, high performing schools) make little or no financial provision, less than RI000 per annum, for classroom space to sit and move around, sufficient textbooks, exercise books, not to mention facilities like laboratories, science equipment, libraries, teaching aids (audio-visual teaching equipment), storage space, chemicals and other consumables.

7. With regard to the availability of most types of equipment and that of additional facilities, a pattern emerges in which the availability and quality of the resources varied almost exactly according to the schools performance categories, from good/adequate in high performing schools to fair/poor/inadequate in low performing schools. Teaching aids, textbooks and exercise books for example were sufficient or fairly adequate in schools with a matriculation pass rate ranging from 100-60 % but insufficient in others, particularly the two schools with a pass rate ranging from 20 to 5 %. The four high performing schools (40%) had libraries and science laboratories and the rest - one high, and five low performing schools - had none of these facilities. Interestingly enough the location of these schools were typical of their status categories, with most of the low performing schools being in more rural settings than the high performing schools.

Finance

8. A majority of the schools (100% of low performing schools and 60%of the teaching of science. If we think in terms of unit financial allocation per pupil the picture is pretty depressing - a low per capita' expenditure. For the majority of schools the unit allocation ranges from 0.0cents

to R1 per child. In the two high performing schools which allocate over R3000 per annum the unit allocation ranges between R10 and R9, 50 per student In 80% of the sample schools, the vote or budget allocation for science is operated by the Heads o£ department. In only two schools (one low and one high performing) do headteachers operate such votes.

Staffing

9. There appears to be an over supply of non-science teachers at grade 12 in the schools examined. These non-science teachers may be viewed as contributing to a low teacher-pupil ratio at grade 12. The tendency to overstaffing is especially strong in the rural schools. Our finding of unit cost per child suggests that a more rational use of teachers would enable essential educational materials to be provided within existing constraints on expenditure. All the science teachers in the study sample commented on how very important it was for the students to have and use learning materials in their science lessons. Unfortunately this was not always the case.

10. The interviews held with the science teachers and headteachers confirm that their morale and teaching methods are influenced by the physical conditions (aesthetics) on ground and materials availability. Being aware that adequate resources and facilities are crucial for a qualified teacher to engage students in effective learning, the teachers strongly recommended that policies should be put in place which stipulate the minimum requirements of physical facilities and teaching resources in all schools at each grade level.

Teachers

11. The study revealed that most of the grade 12 science teachers in the study sample are inadequately trained or qualified, with 80% of the teachers in the low performing schools and 20% of teachers in the high performing schools having only a Diploma - Secondary Teachers Diploma qualification. Most of the teachers admitted that they would not improvise where there are no ready-made visual aids. Teachers especially in the low performing schools lack innovativeness and have conveniently entrenched a culture of dictating or writing notes on blackboards.

12. Within the schools, we found that in the absence of instructional/learning materials or facilities, performance in school/classroom depends very much on the leadership and commitment of the headteacher, and the behaviour of the teacher. In this study, teacher behaviour/commitment was indirectly represented by measures of teaching experience, qualification and professionalism index - notably membership of professional organisation, attendance at in-service courses, subscription to journals and an assessment and feedback index derived from the following activities - giving homework assignments, marking assignments, involvement in co-curricular activities; frequency of classroom tests and main sources of classroom tests. This relationship between teacher commitment, school governance and student performance was clearly manifest in the two top performing schools with a 100 and 75% matric pass rates.

Teaching Methods

13. The most frequently used teaching method in grade 12 science classes in the high performing schools are: - lecturing=>chalk and talk= (20%); guided inquiry method (20%); group laboratory work (20%); small group discussion (40%). For the low performing schools, 60% use the >chalk

and talk = lecturing method, and the remaining two schools claim to respectively use the inquiry method and large group discussion approach frequently.

14. Teaching methods least used. For the best performing schools these were individual laboratory work (20%); independent study (20%); guided inquiry method (20%) and small group discussion (40%). For the low performing schools these were individual laboratory work (20%); guided inquiry method (20%); independent study (20%); small group discussion (20%); and large group discussion (20%). The most prevalent reasons given for the least use of those methods were a) unavailability of science materials and resources (80%); b) time consuming (60%); c) large class (40%).

Science Syllabus

15. In addition many of the teachers particularly in the low performing schools complain that the matriculation science syllabuses are inordinately long and that there is not sufficient time to cover the syllabus adequately. This is often the pretext for skipping practical work; even where equipment is available for teacher demonstration or group work, on the basis that practical work takes up too much class time. The unwillingness or reluctance to engage in practical activity is reinforced by memory-oriented matric examinations that test learned information and not practical skills (or problem solving skills in a practical context). As is the case here in the Northern Province where there are no practical examinations at the end of grade 12. It has to be pointed out once again that not a single one of the low performing schools has a standard allpurpose laboratory.

Recommendations

The negative impact created by this inadequacy or total lack of resources/facilities on student and teacher performance in physical science gives rise to some important recommendations.
1. Improve the equity of provision and distribution of educational materials and facilities for the teaching and learning of science throughout the Province/country.

2. There is need for a definite policy on the funding of science, mathematics and technical subjects in South African secondary schools such that minimum standards are set in terms of unit allocation per pupil.

3. Design and develop science subject and examination syllabuses that reflect the reality on ground in terms of resource availability, so that no one school is unduly disadvantaged in the attempt to follow set syllabuses that call for use of materials and resources that are unavailable in their school.

CLASSROOM OBSERVATION

17 Systematic comparison between the sampled schools 'according to their performance categories showed that a number of important aspects of teaching and learning activities were affected by the quantity and quality of school materials input. These aspects are listed in three groups.

18. First, aspects of teaching affected were a) the extent to which the prevalent teaching methods were learner-centred, where students engage more in interacting with materials and discussions; b) the variety of learning activities in use during the science lessons; c) the variety of interaction patterns and communication methods used in lessons and d) the frequency and types of assessment and feedback procedures used.

19. Second, aspects of classroom learning conditions affected were a) orderliness and ease of movement in the classroom; b) time on learning tasks; c) organisation of the distribution and use of learning materials; d) use of textbooks, supplementary notes and written assignments; and e) pupil attentiveness and discipline.

20. Thirdly, effects were noted for some related variables at school level, namely, a) the range of co-curricular activities, b) teacher morale/commitment and c) breadth of curriculum offered - i.e. school type whether a science only school (like one of the sample schools) or a comprehensive one.

The study examined these three groups of dependent variables in turn, and tried to identify the material inputs, which affected each in the schools observed. Recommendations of the study are in chapter four.

LEARNING MATERIALS AVAILABILITY AND USE IN GRADE 12 SCIENCE CLASSES IN SOME SELECTED SCHOOLS IN THE NORTHERN PROVINCE.

CHAPTER 1

1.1 Introduction

The economic austerity in recent times, coupled with the need for expansion of access to education, have combined to present educational authorities in the new South Africa with increasingly difficult choices in the allocation of available resources. Dilemmas about policy decisions which some two decades ago might have seemed unwarranted inventions, (such as whether to invest in producing more qualified science teachers, or in building more durable classrooms, where both are desperately needed) are today very real.

Post-apartheid South Africa inherited an inequitable and fragmented system of science and technology education, which failed to provide access to a majority of the population. In consequence, less than 0.5% of South African students achieve university entry qualifications in science and mathematics (Naidoo & Lewin 1998). Recent government policy initiatives however, are now focussed on righting the wrongs of the past. One of such measures is the increased investment in science education, aimed at expanding access and improving student performance in science at the primary and secondary school level.

Universalising access to education generally, and increasing investment in science and technology education in particular, are seen as crucial to economic and human resource development strategies.

The findings of a recent study (Naidoo & Lewin 1998) on the impact of increased investment in science education on student achievement in Kwazulu Natal serve to highlight the difficult choices decision-makers have to contend with in the distribution of scarce resources. Based on their findings, the authors questioned the investment policy initiatives of the Provincial Education Department aimed at improving the quality of science education offered. They make the claim that differences in student performance and poor performance generally, may not be simply associated or attributable to levels of resource provision, more likely it is the efficient and effective use of those resources which is important and makes the difference. What was implied in the publication is that some other school internal factors-which were left unspecified- other than the availability of resources alone, may be more critical in determining performance.

Of particular interest, in respect of this study is the issue of resource availability and utilisation with regard to the quality of science education offered. The Kwazulu-Natal study clearly shows that there is a pressing need for extending our knowledge of the ways in which specific school inputs impact on educational processes and outcomes especially in circumstances where resources are limited.

Substantial research has been done over the years on various aspects of the `effectiveness' or `quality' of science education especially in developing countries. Recent research reports suggest that in the South African context, there is inadequate empirical information on how the availability and effective use or otherwise of resources-however defined- are most significant in affecting student learning outcomes in science. Little attention as yet has been given to the ways in which the processes of teaching and learning science, as opposed to the conventional 'results' (examination outcome) of schooling are affected by the availability and use of learning materials, or the effects of their unavailability for that matter. The present study was an attempt to explore that relationship if any, in grade 12 matriculation science classes in the Northern Province.

1.2 Background

Many claims are made about the effect of different resources on student achievement in science. Traditionally, much of school policy in this regard is an attempt at selecting an optimal set of resources-however defined and ensuring that it is available. This study sought information on the reality at school level. Basically the purpose was to investigate the availability and use of learning materials in Grade 12 physical science classes in some selected schools in the Northern Province in order to gain some understanding of the role of learning materials in student science achievement. Through this understanding, it is hoped that the data provided would enable educational authorities appreciate more the schools intrinsic deficiencies that inhibit academic performance in the Northern province.

Secondary science education in South Africa starts in Grade 8 and ends in Grade 12 at the university entrance level. For the first 2 years of secondary school, general science is ' a compulsory subject for all students. . In grades 10, 11, and 12 students may choose the separate subjects of physical science, biology, and mathematics. They are not compulsory for the senior certificate and the matriculation exemption examination taken at the end of year 12. These subjects can be taken at the higher, standard or lower levels, representing different levels of achievement.

Science is widely taught in schools previously designated as reserved for White, Indian, and Coloureds. The African population was largely excluded. According to the FRD Report (1993), 47% and 68% of White students took physical science and biological science, respectively, at matriculation level. The corresponding figures for African students were about 14% and 85%, respectively. Thus, there has been a wide disparity in the participation rates in science subjects among the different racial groups (FRD, 1993). Concerning performance, the Report also stated that, among those taking the matriculation examination, mathematics passes are obtained by only 10% of African students compared with nearly 90% of White students at higher grade matriculation level. In science, only 16% of African students pass, compared to approximately 80% of Coloured, Indian, and White students. Approximately 1 in 312 African students entering school in the mid-1980s obtained matriculation exemption with passes in science and mathematics (FRD, 1993). A glaring consequence of these performance figures is that very few African students pursue science and technology degrees.

Education in the Northern Province

In general, the Northern Province is considered one of the Provinces with the most urgent needs for improvement in education delivery. Inadequate facilities, poorly trained teachers and very

few teachers who qualify in the essential areas of science and mathematics, increasing enrolment and large classes are some of the main issues requiring attention. In addition, the province has high repetition rates especially in African schools, with the former homeland schools being the hardest hit. In 1996 and 1997 the matriculation pass rates were 38% and 41% respectively.
As noted elsewhere in the ANC Education Department document:

> Infrastructure for the teaching and learning of science and mathematics in black schools is poor, especially at the senior secondary level, where material supplied are low quality in terms of relevance and accessibility, and many schools lack laboratories. Fully qualified teachers are few in number, and many schools do not offer physical science and mathematics at senior level. (ANC Education Department, 1994, p.87)

In sum, science education in South Africa, like other sectors in the country suffered considerably from the inequities of the past. The present government views the poor quality of science education as a national crisis and does recognise the need to urgently address this crisis.

The general reform measures needed at the secondary level are multidimensional. A range of priority areas for reform has been identified. (Naidoo & Lewin 1998). These include teacher shortages; enhanced support for teacher education programmes; gender bias; lack of classroom space; lack of equipment and print material/textbooks; inappropriate textbooks, low per-capita expenditure; high student-teacher ratio; assessment procedures; student poor performance; antiquated teaching methods; and weak school leadership.
Although many of these factors have their roots in the historical neglect occasioned by the excesses of apartheid structures of administration and resource allocation, interventions designed to rectify and improve the situation clearly require strategies that go well beyond the simple act of dissembling the structures of the past.

1.3 The Problem Statement

The problem of this study was to provide baseline information on the availability and utilisation of learning materials in grade 12 science classes in the Northern Province. The purpose was to gain some insight into the role of learning materials/resources in student achievement in science.

Research Questions

To this end the following research questions were identified and addressed.

- What types of materials/facilities are available and in use in the identified schools - schools that show a range of performance in matriculation science examination?
- What instructional materials are in use in grade 12 science classes and are they adequate?
- How do teachers implement the science curriculum in grade 12 science classroom? What pedagogical factors such as classroom organisation, student assignments, teaching style etc promote efficient resource usage?
- What effects if any do the availability or non-availability of materials/facilities have on the process of teaching and learning science?

By looking at both `resource' and `process' factors it is understood that the process of teaching and learning is seen both as aspects of the quality of education on offer, i.e. resource provisions, and as links between basic school inputs and students' achievement.

1.4 Research Objectives

Based on the research questions, the objectives of the study were to: -

I) Identify a pool of schools in the Thohoyandou district of the Northern Province that have Grade 12 science classes and select 10 schools whose pupils show a range of performance pass rate (0-100%) in the matriculation science examination.

ii) Profile the selected schools and undertake a survey (an audit) of learning materials in grade 12 science classes.

iii) Observe grade 12 science classes in the selected schools in relation to materials availability and use.

iv) Infer the role of learning materials in pupil achievement in matriculation level

science.

1.5 Significance of study

The data provided by the baseline survey would help generate an empirical framework for policy and decision-makers for addressing the issue of resource provision and use, and improved student achievement in science.

1.6 Conceptual framework

Although research into the determinants of pupil achievement takes various approaches, one of the most appealing and useful has been what education economists call the production factor which focuses on the relationship between school outcomes and measurable educational inputs.

In discussions about how to measure and improve the quality of secondary education two contrasting modes of thought may be distinguished, between which sometimes there is little communication (Urwick &Junaidu 1991). These have been variously described as the `technical efficiency' and `pedagogic' orientations. Each has implications relevant to our study and we have adopted a composite model of the two orientations.

The `technical efficiency' paradigm focuses on the provision of basic school inputs (especially teachers, educational materials and learning time), their effect on academic achievement and the consequent implications for investment. This orientation is characterised by positivist assumptions and by attempts to measure production functions through large-scale surveys. Although for particular inputs, especially the teacher variables, there has been some inconsistency in the findings (Simmons & Alexander, 1978). Nevertheless, substantial evidence exists which shows that the levels of provision of school inputs, textbooks in particular and of other physical facilities in general, are important predictors of academic achievement in schools where these are acutely under-resourced (Heyneman & Jamison, 1980; Mwamwenda & Mwamwnda, 1987).

One of the more general limitations of the `technical efficiency' orientation is its neglect of the `black box' of educational processes, which may explain the relationships measured between educational inputs and learning outcomes. Another general limitation of the `technical efficiency' position is its adherence to the `Coleman doctrine' that school quality should be measured through the `effects of inputs' only (Coleman, 1968, p.18).

The `pedagogic' orientation towards the quality or effectiveness of education does not place much emphasis either on physical inputs or on their effects, but rather sees teaching skills, patterns of school and classroom organisation and curricular content as the essential component of `quality' or `effectiveness'. At its worst, an interpretation of this position is a facile assertion that "some of the best teachers are gurus sitting under trees that good education has nothing to do with books, classrooms".

But this (the `pedagogic') position has, however, been given a fuller (and more respectable) treatment in recent times (Stephens 1989; Hawes & Stephens, 1990). In contrast with the `Coleman doctrine', one of its proponents argues that the quality of schooling should be measured in its processes as well as in its end products (Stephens1989).

Our position is in accord with the latter. The model that we have adopted in this study, deriving as it does from input- process-output principles focuses on the relationship between materials availability and classroom use and student learning outcome. The study takes as a measure of school outcome, the school matriculation examination performance in physical science. Other related studies have used other quantitative measures such as school attendance, dropout rates, and repetition rates. However, for our purpose, the use of school results here, seems a more plausible indicator of school `effectiveness'? The school inputs here refer to the school profile characteristics in terms of resource availability -quality and adequacy, teacher profile characteristics and classroom practice as measured by the respective survey questionnaire instruments.

In sum, our conceptual framework posits that learning outcomes depend on factors `external' and `internal' to the school. On the `external' side, for instance, the policies and financing necessary for schools to operate, the definition and standards of the curriculum, the texts, instructional materials and examination system to implement that curriculum, the provision of staff all of these supporting inputs are on the main external to the school. Internal factors refer to the school culture particularly the leadership style, the behaviour of teachers, their level of professionalism in relation to classroom practice.

CHAPTER 2 METHODOLOGY

2.1 Study and Sampling Design

The study adopted a multi-stage and purposive stratified sampling design. The survey was designed to provide a range of school types at District level based on school matriculation examination results. The population of study comprised all grade 12 science classes in the Northern Province. The sample schools were selected from the Thohoyandou District area in a 3-stage purposeful stratified sampling procedure. In drawing a representative sample of schools we took into consideration the schools with the highest grade level, i.e. grade 12, the rural-urban divide, and a range of school types based on matriculation examination performance in science. Altogether the ten schools chosen represented high, medium and low performing schools with a 100 per cent pass rate at one end and a very poor performance of 5.6% pass rate at the other end of the performance continuum. The schools were from urban, peri-urban, and rural locations. The sample size was largely determined by logistical and time constraints.

2.2 Instrumentation

The study developed, validated and used the following instruments namely, *school profile questionnaire, teacher profile questionnaire, classroom observation schedule and interview schedules* at each school. The development of the instruments involved extensive research deskwork. All the draft instruments were first scrutinised by one or two experts to establish their face and content validity, and subsequently upon review were subject to pilot testing. Findings from the pilot exercise provided valuable basis for further modification where necessary.

<u>*Grade 12 science syllabus*</u>

Both the physical science and biology syllabuses recommend an inquiry approach to the teaching of science. This calls for the availability and effective use of learning materials for quality science education.

To this end, a curriculum analysis guideline was developed for use in analysing the learning material/resource requirements for teaching grade 12 physical science and biology. Based on the analysis, a checklist of basic science materials and facilities necessary for teaching grade 12 science class was compiled.

a) School Profile Resource Questionnaire and Checklist.

This questionnaire sought factual information on the position of resources available for the teaching of grade 12 science classes. The questionnaire was a 23-page instrument consisting of 54 items and two checklists of basic science teaching and learning materials for grade 12 science classes. (See Appendix 1).

The specific items of information required were organised into ten sections labelled A-J namely:

School identity e.g. name and address of school, type of school etc;
School characteristics: - age of school, location, total enrolment, science teacher personnel, time allocated to science;
School expenditure on science: - e.g. annual budget for science, who controls it? Source? etc *Purchase and maintenance of science equipment*
School facilities for teaching science
Teaching methods and materials constraints in grade 12 science classes
Resources availability for teaching specificallyphysical science and biology
Student matriculation performance in science
Checklist of science materials /or grade 12 science classes - their availability and existing condition or state of use.

b**) Teacher Profile Questionnaire**

The 10-page questionnaire consisting of 41 items for grade 12 science teacher mainly sought information on classroom practice regarding learning materials availability and frequency of use, teaching methods and assessment procedure. In addition the questionnaire attempted to document the academic and teaching qualifications of the teachers, their teaching experience, work load and science materials development if any. (See Appendix II).

c) Classroom observation schedule

The observation instrument used a *rating scale* for observing overt classroom behaviours and interactions. The schedule contained a *continuum of attributes* of identified teacher's practice which provides for an observer to observe, evaluate and record at the same time classroom conditions, methods, and patterns of teacher-pupil-material interaction during the course of a lesson. In addition the schedule attempted to document teacher's organisation, distribution and use of learning materials such as textbooks, supplementary notes, worksheets, past examination papers etc. (See Appendix 111).

d) Interview schedules

Semi-structured Interview schedules were developed and used with the teachers observed and with the head teachers of the schools observed. Basically the concern was with their opinion, their views about materials availability or lack of it and how this could affect their morale, efficiency and attitude towards quality science education delivery.

2.3 Data Collection

Data collection was carried out in two main phases.

First phase

(I) The first was an audit phase, which involved a survey of resources available for the teaching and learning of science in the selected schools. The questionnaire contained clear instructions and identified the specific member of staff of the school who should fill the various sections. The role of the research assistant was to ensure that the appropriate person 7 filled the questionnaire and also check on the information given with respect to equipment and facilities.

Difficulties encountered during data collection

Research assistants reported on some of the difficulties encountered in the course of administering the questionnaire.

1. Some of the teachers felt threatened by the questionnaire as they thought that there might be other (possibly political) motivation for the survey besides that stated in the questionnaire.
   For instance where teachers thought that the findings might be used for inter-school comparison to attack or reinforce certain educational policies, there was a tendency to inflate figures or reduce them as the case may be, especially in respect of school matriculation pass rates and equipment.
   Some other teachers might have harboured the impression that there might be an attempt to spread evenly available equipment across schools. In such cases, the teachers tended to reduce the number or quantity of equipment in their schools.

2 Some schools had to be visited several times before responses were obtained. This proved quite time consuming and at times expensive in terms of transportation costs.

3 Some editing had to be done on questionnaire items when scripts were assembled for data input. Some items were such that a response to them precluded a response to the item that followed. For example, "do you like lecturing? YES OR NO"; the next question asked "why do you not like lecturing?" If a respondent had answered `yes' to the first question, he/she was expected to skip the next one. If this was not done, the second response was deleted during the editing.

These difficulties not withstanding a high level of co-operation was obtained from the schools.

Second phase

(II) The second phase consisted of on site visits to administer self-completed questionnaires to selected grade 12 science teachers, and for classroom observations of grade 12 science lessons. A combination of self-completed questionnaires, direct observation (in and out of the classroom) and interviewing of teachers and headteachers was used to obtain data.

For the classroom observation, a teacher of grade 12 science class was identified for observation from each school. In order to minimise inter-school differences in teacher quality, the selection was restricted where possible to class teachers with a minimum of 5-years teaching experience. In the pupil-teacher ratio, another potential source of bias the high performing schools had no advantage except for the one Independent school with a pupil-teacher ratio of 20.1. The rest ranged from 31.5 to 40.1 per teacher.
Three lessons of each grade 12 science teacher were observed using the prepared schedule covering various aspects of classroom conditions, management and pupil behaviour. Systematic observations were also undertaken outside the classroom covering the school site and out door co-curricular activities. Semi-structured interviews were held with the teachers and headteachers of the schools observed.

CHAPTER THREE DATA ANALYSIS AND RESULTS

3.1 DATA ANALYSIS

The following initial observations may be made about the sampled schools. The statistics used were mainly of the descriptive kind involving frequency distributions, mean, and range.

There was some effort to calculate correlations between certain teaching variables and examination performance but the results were not very meaningful.

1. For detailed observation, ten schools were selected in a `purposive' manner to reflect a range of performance in grade 12 physical science examination. For ease of reference in the analysis of data, the schools are conveniently grouped into two categories, notably, *high performing* and *low performing* schools according to range of performance, and are identified by letters.

2. Schools A, B, C, D and E (5 schools) are the high performing schools with percentage pass that ranges from about 50% to 100%; while the low-performing schools, with a success rate below 50%, and ranging from about 5% to 40% are designated, F, G, H, I and J schools.

3. Table 1 shows background information on the sampled schools. All the schools were public schools with the exception of one that was independent. The locations of these schools were typical of their status categories, most of the low performing schools being in more rural settings than the high performing schools. (See Table 1).

4. Although the design of buildings varied very little, the general state of maintenance of buildings and grounds, school internal factors (school culture rating), such as availability of facilities and instructional materials, classroom practice, leadership, order and discipline varied almost exactly according to their performance categories, from good/adequate in schools A-E to fair/poor/inadequate in schools F-J. (Ref. Table 1).

Table 1. Background Information on the sampled schools

School Code	Name	Location	School type	School culture rating	Pupil- teacher ratio	School age(yrs)	Matric (%) performance
A	Mbilwi	U rban	Public	Good	40.6	21	100
B	Tshikevha	Peri-urban	Independent	Good	20.1	12	75
C	Mphaphuli	Peri-urban	Public	Good	35.5	38	66.7
D	Tshivhase	Rural	Public	Good	38.0	51	63.2
E	Fhatuwani	Rural	Public	Fair	31.5	23	47.3
F	Thohoyandou	Urban	Public	Fair	41.1	16	36.5

Table 1 (contd.)

School Code	Name	Location	School type	School culture rating	Pupil- teacher ratio	School age(yrs)	Matric (%) performance
G	Azwifarwi	Rural	Public	Good	43.0	12	26.5
H	Guvhukuvhu	Rural	Public	Fair	34.0	20	20.9
I	Dengenya	Rural	Public	Poor	34.0	14	6.1
J	Nthetsheleseni	Rural	Public	Poor	40.0	11	5.6

With regard to the availability of most types of equipment and that of additional facilities, table 2 shows a similar pattern. Teaching aids, textbooks and exercise books, for example, were sufficient or fairly adequate in schools A B and C but insufficient in others, particularly schools H, I and J. Schools A, B and C had a library other schools had none; schools A, B, C and D had science laboratories and the other schools had none.

Table 2 Equipment and Additional facilities

Rating and availability of basic equipment and facilities

1= adequate; 2= fairly adequate; 3 = poor; 4 = none/ very poor

	SCHOOL									
Item	A	B	C	D	E	F	G	H	I	J
Textbooks	1	1	2	2	2	2	2	2	3	3
Writing materials (e.g. Exercise books	1	1	2	2	2	1	1	2	3	3
Teaching aids (Audio-visuals)	1	1	2	2	2	4	2	4	4	4
Desks per class	3	1	3	3	3	3	2	4	4	3
Chalkboard	1	1	2	3	3	2	1	2	3	3
Preparation room	4	1	3	4	4	4	4	4	4	4
Room to sit and move around	2	2	3	3	2	3	2	4	4	4
Storage space	2	2	3	4	4	3	2	3	4	3

II Whether facilities additional to basic classroom blocks were present

Y = Yes N = No

Item	A	B	C	D	E	F	G	H	I	J
Staff room	Y	Y	Y	Y	Y	Y	Y	N	N	N
Library	Y	Y	Y	N	N	N	N	N	N	N
Science Laboratory	Y	Y	Y	Y	N	N	Y	N	N	N
Science practical kit	Y	Y	Y	Y	Y	Y	Y	Y	N	N
Laboratory Equipment	Y	Y	Y	Y	N	N	Y	Y	N	N
Electricity	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
Water	N	Y	Y	Y	N	Y	Y	Y	Y	Y
Telephone	Y	Y	Y	Y	N	Y	Y	Y	Y	N
Toilets	Y	Y	Y	Y	Y	Y	Y	Y	N	N
Duplicator	Y	Y	Y	Y	Y	N	N	N	N	Y
Sports field	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
Sick bay	N	Y	N	N	N	N	Y	N	N	N
Science resource Centre	N	N	Y	N	Y	N	N	N	N	N
Games equipment	Y	Y	Y	Y	N	Y	N	N	Y	N
Access by road	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Staff strength

Table 3 below, shows the number of teachers per school surveyed and their total student enrolment. As noticed the older schools tended to have more teachers per school with lower teacher-pupil ratio than the relatively new ones. The only notable exception to this trend was the independent school (school B) established twelve years ago. The school had the lowest teacher-pupil ratio.

Table 3 Staff strength and student enrolment

School Code	Total No. of teaching staff	Total No. of student enrolment
A	17	650
B	34	700
C	30	1065
D	35	1322
E	20	630
F	20	817
G	38	1622
H	20	775
I	18	720
J	18	606

3.2 GENERAL MANAGEMENT

This section deals with five issues that are of general importance to all the schools surveyed. These are: -

1. Curricular provisions
2. Financial provisions
3. Purchase of equipment and materials.
4. Journals subscribed to

3.2.1 Curricular provision

Under this section, information is provided on four questions, namely: -

a) How many grade 12 classrooms are available in each school?

b) What is the total number of grade 12 teachers and grade 12 pupils?

c) What is the total number of grade 12 science teachers and grade 12 science pupils?

d) What time allocation is provided for science subjects taught in grade 12 classes?

Table 4 displays the distribution of teachers and pupils in grade 12 classes according to subject matter in the schools surveyed.

The data gives some insight into classroom conditions. The following trends may be observed. The average class size (pupil - classroom ratio) for both high performing(schools A, B, C, D, E) and low performing (schools F, G, H, I, J) schools is 55. But this average class size drops to about 23 in science classes.

The average teacher- pupil ratio for all grade 12 classes in the schools sampled is 10,1 for the high performing schools and 9.5 for the low performing schools. But this teacher-pupil ratio is seen to increase quite substantially in grade 12 science classes. For schools A, B, C, D, E, the average ratio is 24.4, and for schools F, G, H, I, J, the figure is 37.1. In other words the non-science teachers may be viewed as contributing to a low teacher-pupil ratio at grade 12 in the schools sampled.

Table 4: Distribution of teachers and pupils in grade 12 classrooms in the schools

	SCHOOL CODE									
	A	B	C	D	E	F	G	H	I	J
No. of grade 12 Classrooms	2	1	2	4	2	1	5	2	1	2
No. of grade 12 Teachers	7	4	15	12	15	10	14	12	10	14
No. of grade 12 Pupils	79	34	129	200	108	54	220	105	62	13
No. of grade 12 Science teachers	2	3	2	2	1	2	1	1	1	1
No. of grade 12 Science pupils	79	12	37	82	34	25	85	32	34	46

Two assertions may be made in relation to class size and teacher- pupil ratio at grade 12. First, compared with teachers in non-science subjects, science teachers are few and the average class size in science is generally higher than in the other non-science subjects. Secondly, a high pupil to teacher ratio in grade 12 science classes, especially in the low performing and under-resourced schools (37.1) is likely to make it difficult to implement the more intense learner-centred approaches favoured in science education.

Interestingly enough, we also note from Table 4, that, the average non-science teacher to science teacher ratios for both high and low performing schools are 5.4 and 10.1 respectively. Thus, on the face of it, there appears to be an over supply of teachers in non-science subjects, which seems to be more apparent in the rural, low performing schools. If that is the case, perhaps a more cost-effective mechanism of teacher deployment would enable essential learning materials and facilities to be provided within existing constraints on expenditure.

3.2.2 Time allocation to science subiects

Table 5 shows the mean time allocation in minutes per week for the science subjects taught in grade 12. The following trends may be noted.

1. There is considerable uniformity in time allocation for both biology and physical science. Specifically, the typical time allocation is 240 minutes for biology and physical science. The average weekly provision for both biology and physical science is about 7.5 hours for both categories of schools. However, exceptions are found in two low performing schools where 35 minutes and 480 minutes were allocated (See Table 5).

Table 5 Mean number of minutes. allocated weekly to science subjects at grade 12

School Code	Biology (mins.)	Physical science (mins.)
A	240	240
B	225	225
C	240	240
D	160	160
E	245	245
F	240	240
G	240	240
H	35	35
I	240	280
J	480	480

3.2.3 Financial provisions

Under this heading two basic kinds of information were sought namely:-

a) How much money is typically budgeted annually for science teaching?

b) Who operates the budget?

Table 6 shows the different levels of provision for the schools' annual budget for science.

Table 6: Schools' annual budget for science

School code	No provision	Below R1000	R1001-2000	R2001-3000	Above R3000
A					X
B					X
C		X			
D			X		
E		X			
F		X			
G		X			
H		X			
I		X			
J		X			

As shown in table 6 a majority of the schools make very little provision, less than R1 000 per year for the teaching of science. The notable exceptions are schools A and B of the high performing status. It should however be noted that school A is an all-science school, and school B, the only independent school in the survey. It is perhaps understandable that these two schools for obvious reasons were likely to make greater efforts at providing additional resources.

But, if we think in terms of unit financial allocation per pupil, the picture is pretty depressing. In a majority (60%) of the schools, it is about RI per child. In schools which make a financial provision of below R1000 per annum, the average unit allocation ranges from 60 cents to R1.40 per child. In the other two schools (A and B) which allocate over R3000 per annum (See table 7), the average unit allocation ranges between R10 and R9.50.

Who operates the budget?

Our findings show that in 80% of the schools surveyed, the heads of department of science operate the budget allocation for science. In only two schools did we find the headteachers responsible for handling the science budget.

Expenditure on science equipment and materials

Table 7 below displays the average annual expenditure on science equipment and materials by the individual schools. The combined expenditure for schools A,B,C,D,E, is R14,798; and for schools F,G,H,I,J the comparatively paltry sum of R2,700.There is clearly a wide disparity in science materials expenditure within and across high and low performing schools.

Table 7: Schools'expenditure per year on science materials and equipment.

School code (High performing)	Amount (Rands)	School code (Low performing)	Amount (Rands)
A	7000	F	950
B	5000	G	500
C	180	H	250
D	2000	I	None
E	618	J	1000

3.24 Purchase Of Equipment

In this section, information is sought about: -

a) Sources from which science equipment is purchased
b) Who is responsible for the purchase of equipment
c) Who compiles the list of science materials to be purchased
d) Existing guidelines if any, on science materials to be purchased.

There was scanty information on companies that supply or service school science equipment.

Sources of science equipment

1. In all the schools surveyed the respondents noted that science equipment and science practical kits are supplied or purchased locally. There are no foreign suppliers.

Purchases of equipment

Table 8 Body responsible for the purchase of science equipment/materials

School code	Entirely by the school	Entirely by the Provincial Education Dept.	Partly by school and partly by Educ.Dept.
A	X		
B	X		
C			X
D		X	
E			X
F	X		
G			X
H	X		
I			X
J		X	

.

Our findings showed that the persons or bodies responsible for the purchase of science materials and equipment also compile the lists of materials and equipment to be purchased. But where the purchases are the responsibility of both the Provincial Education department and the schools concerned (Schools C, E, G and H) the compilation is a joint effort.

Grade level at which practical science kits are first provided

Schools vary in the grade level at which pupils are first provided with science kits. About 40% (Schools A, C, F, and I) are first supplied with science kits at grade 8. In two of the low performing schools (Schools Hand J), practical science kits were not available.

In the one independent school, practical kits are first provided at grade 5. The remaining three schools in the survey are first given science kits in grade 10 (school I) and grade 12 (schools D and G).

What this means is that in some schools pupils have access (or perhaps none at all), to science equipment maybe only in the last year of their secondary level education. The pupils most disadvantaged in this regard are those in **the** low performance category schools.

Policy guidelines on supply of science kits

We note that there are no existing policy guidelines as to what learning materials or apparatus are to be included in the science practical kits. The decision is left to the suppliers. They determine what science materials or equipment are to be included for the various grade levels.

Maintenance of science equipment

Out of the ten schools surveyed, six (five low performing and one high performing) did not employ the service of any maintenance company. This was the situation probably because none of these schools had functional laboratories. Four out of the five high performing schools make provision for the maintenance/servicing and replacement of equipment. Various companies are used to service school equipment. Industrial establishments, sometimes provide funds for this purpose.

3.2.5 Journals subscribed to by schools

This section examines the extent to which schools subscribe to journals in the areas of science and mathematics. The following observations were made.

1. Only one of the schools (school B-Independent) subscribed to any journal in science at all.

2. The situation is even more disturbing in that many of the respondents do not even seem to know what a journal is. Many of the items listed were in fact teachers' manuals.

There is clearly a need for a science teachers' journal in the Region. Such a journal should provide the forum to disseminate well-written articles on theory and practice in science and mathematics education. Regular subscription to a journal of this nature by teachers and institutions should (a) encourage and promote a professional attitude in the teachers and (b) act as a means for continued professional growth and formation.

3.3 All-PURPOSE LABORATORY

All-purpose laboratories are those used predominantly for General science but sometimes also for the single science subjects. In this section, some of the characteristics of such allpurpose laboratories are summarised for the schools surveyed.

In order to judge the adequacy or otherwise of these characteristics the standards used by Stone (1960) elsewhere in Africa are applied. Stone assumed a class of 30 for the following standards:

A Floor Space Area

Over 120 sq. metres - Very large

108-120 sq.metres - Ideal
96 - 108 sq. metres - Acceptable minimum
85 - 96 sq. metres - Too small
Less than 85 sq.m. - Quite inadequate

B. Number of Water taps/sinks

More than 12 - Generous
8-12 - Optimum
5-7 - Acceptable standard
Less than 5 - Inadequate

C. Number of Gas taps

30 or more - Adequate
10-29 - Acceptable minimum
Less than 10 - Inadequate

We are not aware of any publication on standardization of equipment by the Provincial or the National Ministry of Education, which contains specifications in respect of dimensions or fittings of laboratories. So we will make do with the Stone specification.

Table 9: Characteristics of All-purpose laboratories in the schools.

Items	Schools									
	A	B	C	D	E	F	G	H	I	J
Area in sq.m	105*	50*	60	-	N/A	N/A	110	N/A	N/A	N/A
No. of Prep. rooms	1	1	2	N/A	N/A	N/A	1	N/A	N/A	N/A
No. of storage rooms	N/A	1	2	1	N/A	N/A	1	N/A	N/A	N/A
No. of water taps	N/A	2	N/A	12	N/A	N/A	5	N/A	N/A	N/A
No. of gas Taps	N/A	5	N/A	N/A	N/A	N/A	6	N/A	N/A	N/A
No. of electr. Points	2	2	2	7	N/A	N/A	7	N/A	N/A	N/A

N/A = Not available or none

*For school B the class size is 20, therefore, the laboratory floor area meets the minimum requirement. Only one other school (school A) in the survey met the minimum specification. About 50% of the schools sampled have no laboratories, and the majority of those (80%) belong to the low performing schools. For the three items where we have some standard specification, an asterisk indicates that the school meets the minimum requirement for that item (see Table 9).

In most schools with laboratory, the typical number of preparation room is 1 and this is considered adequate.

The typical number of storage room is one, in the schools that have them and this number is acceptable.

Only one school meets the minimum acceptable standard for the number of water taps. On number of gas taps, none of the schools meets the minimum acceptable standard. Regarding electric points there are no official specified standards to judge with. There is however considerable variation from school to school, from a low of 2 in about 3 schools to a high of 7 in two schools.

It is clear that basic facilities and infrastructure for the teaching and learning of science especially in the low performing schools of F,G, H, I, J are generally poor, where virtually all the schools lack laboratories.

All the grade 12 science teachers interviewed, with no exception categorically indicated that the schools were insufficiently supplied in terms of science teaching and learning materials for grade 12 classes.

3.4 School Science Achievement

When asked to indicate what in their opinion was their grade 12 students' highest achievement in science in the last three years of which the school is most proud of, the teachers' responses were as follows: -

Schools	Responses
A	Winning the 1997 national science exposition competition
B	winning a bronze medal in the 1997 science exposition
C	Finalists in the national science exposition, 1995, 1996, 1997
D	Participated in the national science exposition E None
F	Participated in the national science exposition competition
G	Three students passed physical science grade 12 examinations
H, I, & J	None

The responses themselves tend to further confirm, albeit, in an indirect way, the individual school's performance status category. The system seems to be locked into a vicious cycle, in which poorly prepared teachers, in under resourced classrooms in turn produce weak and poorly prepared pupils. The teachers themselves feel that lack of teaching resources help to undermine their professional credibility and morale, which in turn contribute to the poor quality education that pupils receive. The schools'sense of achievement, or sense of worth or lack of it, is clearly reflected in those responses.

3.5 APPROACHES AND CONSTRAINTS TO TEACHING GRADE 12 SCIENCE CLASSES

The successful learning of any subject by pupils depends, to a large extent on circumstances surrounding the teaching of the subject. These circumstances of necessity must include specifically the methods of teaching as well as the constraints to teaching and teaming.

In this section, both aspects of the circumstances surrounding the grade 12 science teaching have been investigated. Although school by school comparison is available, only the general data are provided (Table 10). This is done for the following reasons

1. The responses are very similar across schools.
2. The comparisons between different teaching approaches and between different constraints are more meaningful for policy formulation than the minute school by school comparisons.

3.5.1 Approaches to Teaching

In this section, three main categories of approaches were investigated, namely;

1. Approaches to instruction within the classroom or laboratory.
2. Homework assignments.
3. Co-curricular activities

Approaches to instruction

Here a list of various approaches to instruction in the classroom is given and the time devoted to each approach. The results are presented in Table 10 below.

The overall findings are as follows:

1. The most prevalent approaches to instruction are (a) teaching or explaining new content to the whole class, (b) revising old content-content not new-with the whole class, (c) whole class discussion and (d) demonstrations and experiments by the teacher.
2. Relatively little or no time is devoted to (a) teaching or revising in small groups, (b) improvising learning aids/materials by teachers, (c) using audio-visual equipment for

teaching, (d) pupils doing practical work on their own, and (e) going on excursions and field trips in most schools.

3. Maintaining discipline in science class appears to be a problem in about 60% of the schools, where fair to great amount of time is spent on this activity.

Table 10: Time devoted to different approaches to teaching science in grade 12.

APPROACHES	No time	Little time	% of Schools Devoting Fair time	Great time
1. Teaching or explaining new Content to whole class	0.0	0.0	40.0	60.0
2. Teaching or explaining new content to small groups	0.0	90.0	10.0	0.0
3. Revising old content with entire class	10.0	10.0	50.0	30.0
4. Revising old content with small groups	10.0	50.0	20.0	20.0
5. Whole class discussion	0.0	20.0	50.0	30.0
5. Using audio-visual equipment for teaching	40.0	40.0	20.0	0.0
6. Constructing or improvising learning aids/materials	0.0	70.0	30.0	0.0
7. Pupils collecting plant and animal specimens	20.0	50.0	20.0	10.0
8. Demonstration and experiments by teacher	0.0	40.0	40.0	20.0
9. Pupils individual practical work	20.0	80.0	0.0	0.0
10. Going on field trips and excursions	20.0	50.0	20.0	10.0
11. Establishing order and discipline in class	0.0	40.0	40.0	20.0

3.5.2 **Home work assignments**

The use of homework assignments was investigated in respect of the average number of assignments and the time spent weekly on them for grade twelve science subjects. The findings are displayed in Table 11 below.

Table 11: Number of, and time spent weekly on students' assignments in grade 12 science subjects

School code	Mean no. of assignments	Mean no. of hours to complete assignment	Mean no of hours to mark assignment
A	7	5	4
B	2	2	6
C	3	12	8
D	3	24	20
E	3	6	3
F	1	3	6
G	4	4	6
H	5	3	3
I	3	8	16
J	3	3	1

The findings show that:

1. On the average, schools give 3-4 homework assignments a week. The average for the high performing schools is 3.6 and for the low performing is 3.3 . There is similarity between the two categories of schools in the number of assignments given to pupils.
2. The average number of hours spent weekly on completing homework assignments in the schools surveyed is 7 hours. However there is greater variation between schools in the number of hours required weekly for pupils to complete homework assignments. Figures range from a low of 2 hours in a high performing school to a high of 24 hours in a low performing school (see Table 11).
3. When we recall that the average number of hours allocated weekly to physical science and biology subjects in schools is 7.5 hours, (ref. Table 5) it would appear that pupils spend about 90% (7hours) as much time on homework assignments as they spend in the classroom.
4. The average number of hours spent by teachers on marking homework assignments is 7.3 hours. Although there are variations from school to school, six (60%) of the schools report that 6hours and over per week is devoted to marking homework assignments.

3.5.3 Co-curricula activities

This section investigated the extent to which three specific activities are organized to complement or supplement the teaching of grade 12 science subjects. The three activities are:

1. - having guest speakers on specialized topics in science.
2. - holding exhibitions and science fairs
3. - holding school debates and symposia.

The findings are summarized in Table 12 for the respective high and low performing schools.

Table 12. Frequency of organizing science –related activities in high and low performing schools

ACTIVITY	% FREQUENCY					
	Never		Rarely		Often	
	High	Low	High	Low	High	Low
1. Guest speakers on specialized topics	60	60	20	40	20	0
2. Having science fairs or exhibitions	20	60	40	40	40	0
3. Having symposia or debates in science	20	60	40	40	20	0

1. In all three areas, the most frequently organized activity is the science fairs/exhibition, particularly in the high performing schools. We note that out of the ten schools sampled, it was only the one independent school that frequently organized these co-curricula activities.
2. In general all three activities are used only rarely if at all in the schools. The number of schools where all three activities are never organized is pretty high, about 60% in the low performing schools and 20-60% in the high performing schools.

3.5.4 Constraints to teaching grade 12 science classes

In this section the extent to which certain known constraints to teaching and learning affect the teaching of grade 12 science classes is investigated.

The findings are summarized in Table 13.

1. All the schools both high and low performing ones (90%) report that a majority of the listed constrains (90%) are serious or very serious.

Table 13: Seriousness of various constraints to the teaching of grade 12 science classes in all schools sampled

CONSTRAINT	% SCHOOLS PERCEIVING AS		
	Not serious	Serious	Very serious
1. Lack of qualified teachers	80.0	10.0	10.0
2. Lack of laboratories	20.0	30.0	50.0
3. Large class	30.0	10.0	60.0
4. Lack of textbooks	30.0	30.0	40.0
5. Lack of audio-visual aids	30.0	20.0	50.0
6. Lack of teaching / learning materials	20.0	70.0	10.0
7. Dissatisfaction with teachers' salaries	30.0	30.0	40.0
8. Dissatisfaction with teachers' conditions of service	30.0	20.0	50.0
9. Poor background of pupils in			
(i) English language	10.0	60.0	30.0
(ii) Science	10.0	50.0	40.0
(iii) Mathematics	0.0	40.0	60.0
(iv) Manipulative skills	20.0	30.0	50.0
10. Inadequate funds	10.0	30.0	60.0

2. The most prevalent constraints for both groups are:
   (a) poor background of pupils in mathematics, English language and science.
   (b) large classes
   (c) lack of teaching and learning materials
   (d) lack of laboratories
   (e) inadequate funds
   (f) lack of audiovisual aids

3. For the low performing schools teacher dissatisfaction with salaries and conditions of service were perceived as serious or very serious constraints.

4. In general, the <u>least serious</u> constraints for the high performing schools were:

   (a) dissatisfaction with teachers' salaries
   (b) dissatisfaction with teachers' conditions of service
   (c) lack of qualified teachers
   (d) lack of textbooks

5. The least serious constraint for the low performing schools is lack of qualified teachers Interestingly enough it is in the low performing schools that you find the least qualified science teaching personnel.

Other constraints, which were specified by the respondents, included:

-lack of experienced expert teachers to handle large under-resourced science classes, -

-lack of teacher of teacher motivation

-lack of access to electricity

-memory oriented examinations which force teachers to use coping strategies of teacher-centred methods.

Comment

The approaches to teaching by teachers of grade 12 science as reported in this survey are very traditional. The teacher typically assumes the dominating role of teaching to or discussing with the entire class adopting predominantly the chalk and talk method. Work with individuals or small groups which learning by inquiry typically require is given very little time in the repertoire of the teacher. Lack of laboratory materials, large and overcrowded classes, lack of audio-visual aids, and lack of qualified and motivated teachers further aggravate this state of affair, particularly in the low performing schools.

Some other pedagogic out-of- school scientific activities that characterize the superior and innovative teacher are also largely missing in the schools (see Table 12). These are the co-curricular activities such as science clubs, inviting guest speakers, holding science fairs and exhibitions, organizing debates and going on excursions. Lack of funds probably aggravates the situation. But one must admit that there is quite a lot in the area of co-curricular activities that an imaginative teacher can achieve with scarce financial resources.

Some of the constraints are related to pupils themselves, especially as regards their previous learning experiences and entry behaviour to instruction in secondary school science. In particular, are the effectiveness or otherwise of mathematics, English language and science teaching at the primary school level.

It is interesting to note that lack of textbooks is perceived as one of the least serious constraints to teaching. It may well be that the supply and distribution of text materials at this level (grade 12) has been more effective than the public is wont to think. It would appear that a majority of grade 12 pupils have access to science textbooks and that these are frequently used in class.

There is certainly evidence as will be shown later, in subsequent section on classroom conditions that the provision of science textbooks and writing materials are critical to the way in which grade 12 science is taught in the schools surveyed. But as far as other teaching and learning resources are concerned, it was the opinion of all the teachers surveyed that, their grade 12 science classes were poorly resourced or under-resourced as far as provision of learning materials for teaching the recommended science syllabuses is concerned. Teachers' perception of resource availability is crucial to the way the classrooms are managed.

Perhaps it needs to be pointed out here that, science curriculum studies in Africa provides limitless opportunities for research into alternative resources not only for teaching traditional topics in biology, chemistry and physics, but also to seek appropriate alternative topics through which the subjects' essentials maybe presented. Many standard experiments could be replaced by or substituted with simpler ones, which could achieve the desired objectives. Not only is this likely to be cheaper, the socio-cultural relevance of science and science education is enhanced by the use of local materials from the immediate environment.

The quality and quantity of school physical inputs as we have seen clearly affect the activities and methods employed by the teachers. These inputs are factors, which help structure, the learning situation more directly and help determine the extent to which teaching methods were pupil-centred. Thus, the non availability of a number of teaching resources and facilities such as laboratory materials, teaching aids, storerooms, audio-visual aids means that in most of the grade 12 science classes it is the textbook that drives both teacher instruction and pupil learning.

Also, the variety of activities organised during lessons and the frequency with which assignments and homeworks were set, were mostly determined by the availability and use of textbooks as the main source of information.

Teachers' salaries and conditions of service inspite of being perceived as the least serious constraints in the high performing schools, but considered serious in the low performing schools to teaching are nevertheless strong factors in the building of the morale of the teacher.

In sum, the findings on approaches and constraints to grade 12 science teaching have implications for policy and practice, not only for teacher education but also for the financial and administrative support of the educational process.

3.6 <u>Resources and performance in trade 12 science classes</u>

This section deals with information about specialised laboratories. Information was sought on available laboratory equipment and material, in respect of physical science and biology. Specifically, the following items of information were obtained.

I Number and area of floor space of laboratories

2 Number and area of floor space of preparation rooms

3 Number and area of floor space o£ laboratory stores

4 Number of water taps per laboratory

5 Number of electrical points per laboratory

6 Number of each of a list of items of laboratory equipment and material for grade 12 science.

In order to approximately assess the adequacy of the existing provisions some of the

(A) Laboratory floor space

Very large -	More than 160 sq.metres
Ideal-	144- 160 sq. metres
Acceptable minimum -	123 - 143 sq. metres
Too small-	113 - 127 sq. metres
Quite inadequate -	Less than 113 sq. metres

(B) Number of water taps/sinks

	Physics	Chemistry	Biology
Ideal -generous -	more than 4	more than 9	more than 9
Acceptable minimum -	1-4	7-9	5-9
Inadequate -	0	less than 7	less than 5

Number of laboratories

The following are the main findings: -

1. For the high and low performing schools the mean number of physical science laboratories is 0.8 and 0.2 respectively. In other words, there is on the average almost one laboratory for every high performing school (i.e. 4 laboratories for every 5 schools). On the other hand for the low performing schools, there is on the average one laboratory for every five schools. Ideally there should be one laboratory per school.

2. A look at the distribution of all-purpose laboratories in the different schools also show the same pattern of distribution, with the low performing schools being the least provided and the high performing the best provided.

Area of laboratory floor space

On the average for the five high performing schools, the available floor space for physical science laboratory is 65 sq. metres. Using our established standard, which stipulates 128 sq. metres as the acceptable minimum (for 40 pupils), this minimum is not met in physical science laboratories in the schools.

Number of preparation rooms

On the average, there is the same number of preparation rooms as there are laboratories for both categories of schools. There are 4 preparation rooms to 5 laboratories in the high performing schools and one preparation room to five laboratories in the low performing schools

Area of preparation rooms

There are no set standards to judge adequacy or inadequacy, however Savage (1964) recommends 24 sq.metres. The average for the schools surveyed is 12 sq. metres for laboratories. This figure does not seem adequate in the schools, which have preparation rooms.

Number of storerooms

1. For the high performing schools the average number of storerooms is 0.8. In other words 4 store in every 5 laboratories

2. There are variations from school to schools in number of storerooms but most schools approach the ratio of 1 storeroom per laboratory.

3. In the low performing schools there is a marked variation in which one of the schools claim to have 5 storerooms and the remaining 4 schools none.

Number of water taps for the laboratory

Using the extrapolated standard from Stone (1960), it is clear that provision of water taps is quite inadequate in most schools. There are some exceptions notably in school D where the provision is rather generous (10 taps) and school G where the number meets the acceptable minimum standard.

Number of electrical Points

There is no set standard available by which to judge the adequacy of provision. However the average for the high and low performing schools is 2.2. and 1.2 respectively per laboratory. This appears inadequate. Four out of the five low performing schools had no electrical points since they had no laboratories.

Number of gas points

1. The average gas points per laboratory for the low performing schools is 0. For the high performing schools the average is 3.6 per laboratory.

2. There is wide variation from school to school (i.e. schools with laboratories) ranging from 0 to 13 gas points. Most of the schools surveyed do not have functional gas points in the laboratories.

It is interesting to note that among the schools that have laboratories, 60% of these laboratories have no gas points, 20% no electricity, 40% no water taps and 40% no preparation rooms.

3.7 Number and condition of items of laboratory equipment and materials for grade 12 science

The findings in respect of laboratory equipment and materials and their state of repair or disrepair are summarized below.

In conducting this survey a prepared list of basic equipment /materials for grade 12 science were compiled using the science syllabus. The questionnaire sought four items of information on each equipment as follows: (i)- availability or non-availability, (ii) item in good condition, (iii) item in fair condition and (iv) item in poor condition.

The following trends were observed:

1. A majority of the low performing schools (60%) did not have the most basic laboratory materials and equipment. More specialized equipment such as ammeters, weighing balance, burettes, stop clock, pH meter, fume cupboard, galvanometer, Liebig condenser, rheostat, Kipp's apparatus, ticker timer, fractionating column, reagent bottles, etc. were not available in over 80% of the schools surveyed. But where the equipment are)available, these were well maintained and in good condition.

2. In the high performing schools, a majority (60%) had basic equipment to perform classroom demonstrations, but at least 40% of the schools did not have the specialized equipment such as those listed in 1.

3. A high proportion of equipment available in schools was in poor condition: These became largely junk cluttering up the laboratories or storerooms. The situation being worse in physical science and least in biology. The incidence of damaged equipment or equipment in poor condition or lack of materials is highest in the chemistry component of the physical science syllabus.

4 There was a curious imbalance in the supply of equipment, some materials being oversupplied while many were under supplied. Biology laboratory materials are better supplied than physical science materials and equipment for both categories of schools.

Comment

It would appear that the rapid expansion of schools as a result of expanding access to science education has led to the neglect (probably for financial reasons) of provision of separate laboratories and laboratory materials for the natural sciences. There is evidence that in many of the schools in the Northern Province only one all-purpose laboratories rather than separate laboratories are provided.

Some of the science equipment itemized in the science laboratories shows the result of improper guidance to the science teacher in laboratory stocking and management. The result is that many items of equipment are over-supplied while many are under-supplied

We also observed that most schools do not keep appropriate laboratory records such as inventories, breakage, books, etc. This made the checking of available equipment a most arduous task.

Once again we note that the methods the teachers frequently employed to teach science are to a very large extent influenced by the kind of resources and facilities available in the school. The methods in turn influence the degree of participation and performance by pupils. In general, where learning materials and facilities are inadequate, the teaching approach inevitably tends to be teacher-centred. A teaching approach that centres on the teacher is bad for science teaching and learning and soon kills interest. But where facilities and resources are available, a qualified and motivated science teacher will deploy methods that centre on the learner. Such was the case in two (schools A and B) of the high performing schools. The schools emphasized to a reasonable extent pupil's self- activity with learning materials in solving problems and group project work.

There is clearly a critical role played by materials availability and use in effective teaching and learning of science.

3.8 TEACHING PERSONNEL

Teachers are an indispensable resource in teaching and learning of science, but as the study revealed they can be rendered ineffective by any one or combination of the following factors:

- lack of visual aids, textbooks, or needed teaching materials
- poor training, poor qualifications or inadequate in-service programme
- under-resourced large science classes

Tables 14 and 15 display the characteristics of the teaching personnel for grade 12 physical science classes in the schools surveyed. It shows the number of teachers with different combinations of academic and professional qualifications.

Table 14. No. of teachers with various qualifications teaching grade 12 physical science classes in the schools sampled

School Code	Graduate with teaching Qualification	Graduate without teaching Diploma qualification	3-year T eacher Diploma	Matric level physical science	Other
A	1	0	0	0	0
B	1	0	0	0	0
C	0	0	2	0	0
D	2	4	4	4	0
E	3	0	2	1	0
F	1	1	1	1	0
G	3	0	1	0	0
H	1	3	3	4	0
I	0	0	4	4	0
J	1	0	1	0	0

Table 15 : %age of Teachers of science in the schools sampled grouped according to academic and professional qualification

Qualification	Graduate, 3 year diploma with professional qualification	Graduate without professional qualification	3 year Diploma	Matric level (other)
Percentage (%)	24.0	14.8	33.3	29.6

The following observations may be made.

1. Approximately 65% of the grade 12 physical science teachers sampled received their education at teacher training colleges for a 3-year diploma or at matriculation level. And approximately 24% trained at universities for a 4-year degree or 3 year degree with 1-year teacher's professional diploma.

It is often thought that the shortage of qualified teachers is a major contributor to the poor performance of pupils in grade 12 physical science examination.

2. The lowest percentage of teachers with adequate academic qualifications is found in the low performing schools.

Teaching Experience

The study revealed that the most experienced teachers of physical science are found in the high performing schools. A substantial percentage (50%) of the teachers have less than six years teaching experience and these are predominantly in the low performing schools. The probability is therefore that relatively inexperienced teachers in those schools are teaching physical science.

Membership of *professional organization*

In general, very few teachers belong to any professional science teachers' association. The teachers identified as belonging to a professional organization were from the high performing schools.

The overall picture of the teaching personnel in respect of appropriate qualifications is not altogether bad, but there is still considerable for improvement. This improvement is even more compelling for teachers in the low category status.

3.9 CLASSROOMS: Materials Availability and Use.

Systematic comparison between the sampled schools showed that a number of important aspects of teaching and learning activities were affected by the availability or otherwise of physical inputs. These aspects will be listed and discussed under various sub- headings frequency of use in grade 12 science classes.

Table 16 : Materials availability and Frequency of use in the schools surveyed

Availability: 1=Yes; 2= No   *Frequency of use*: 3= Never; 4 = Seldom; 5 = Often; 6 = Always

ITEMS	SCHOOLS A	B	C	D	E	F	G	H	I	J
Teaching aids (charts etc)	1– 4	1 –5	2 –3	1 – 5	2 – 3	1 – 5	1 – 4	2 – 3	1 - 4	2 - 3
Audio-visual equipment	1 - 5	1 - 5	2 -3	2 - 3	2 - 3	2 - 3	1 - 4	2 - 3	2 - 3	2
Textbooks	1 – 5	1 – 6	1 – 6	1 – 6	1 - 6	1 - 6	1 - 6	1 - 6	2,- 6	2, 6
Chalkboard and chalk	1 –5	1 - 6	1 - 6	1 - 6	1 - 6	1 - 6	1 - 6	1 - 6	1 - 6	1 - 6
Educ. Video cassettes	1 - 5	1 –6	1 – 6	2	1 – 4	2 – 3	2 – 3	2 – 3	2 – 3	2
Library books	1 – 5	1 – 5	2 – 3	2	2 – 3	2 – 3	2 – 3	2 – 3	2 – 3	1 –5
Science practical kits	1 – 5	1 – 6	1 – 4	1 – 6	1 – 4	1 – 5	1 – 4	1 – 6	2 – 3	1 –3
Worksheets	1 – 5	1 – 4	2 - 4	2 – 3	2 – 3	2 – 3	2 – 3	1 – 6	1 – 5	2 –3
Teaching models	1 – 4	1 – 5	2 – 3	1 – 5	2 – 3	2 – 3	2 – 3	1 – 6	2 – 3	1 -5
Improvised teaching and Learning materials	1 – 5	1 – 6	1 –5	2	2 – 3	1 – 6	1 – 6	1 – 6	1 – 6	1 –6
Exercise books	1 – 6	1 – 6	1 – 6	1 – 5	1 – 6	2 – 3	2 – 3	2 – 3	2 – 3	2 –3
Supply of consumables	1 – 6	1 – 5	2 – 3	1 – 5	2 – 3	2 – 3	2 – 3	1 – 5	2 – 3	2 –3
Science materials for teacher demonstrations	1 – 5	1 – 5	1 – 5	1 – 5	1 – 5	1 – 5	1 – 5	1 – 5	2 – 3	1 –4
Science materials for individual activity	1 – 4	1 – 4	2 – 3	2 - 3	2 – 3	2 – 3	2 – 3	2 – 3	2 – 3	2 - 3

Practical work

Much of the practical activity carried out in the schools comes in the form of teacher demonstration. Practical work according to the teachers is mainly used for the verification of theory rather than for problem solving in a practical context. A majority of the schools (see Table 16) do not have sufficient equipment or materials for individual practical work. It emerged from discussion with the teachers that some feel that the science syllabus, especially grade 12 biology is inordinately long and that there is not sufficient time to cover 33 the syllabus adequately. This is often the pretext for skipping practical work, on the basis that practical work takes up too much class time, even where equipment and teaching resources are available. This apparent reluctance on the part of the teachers to engage pupils in practical activity is bolstered by the grade 12 matriculation examination, which tests memorised knowledge and not practical skills.

Note taking

All the teachers claim that their pupils are always involved in note taking. For the high performing schools, 60% of the teachers indicate that their pupils make their own notes and the remaining 40% say that notes are mainly given by the teacher through chalkboard summary. For the low performing schools, 60% of the teachers say that notes are mainly given by chalkboard summary and 40% dictate notes to the pupils.

The source most frequently used to develop notes is the prescribed textbooks. However the high performing schools claim that other textbooks outside the prescribed ones are also used.

Textbooks

For the high performing schools 80% of them indicate that all the pupils have textbooks for grade 12 science. The figure is lower (60%) for the low performing schools. For the remaining schools pupils share on average 1 book to 3 pupils.

Interestingly enough, textbooks are used for various reasons. On the one hand, for the high performing schools, 60% of grade 12 science teachers use textbooks mainly for homework exercise and 40% of them to gain more understanding of topics to be taught. On the other hand, for the low performing schools, 40% of the teachers use textbooks mainly to give class exercises, 40% to gain understanding of the topics to be taught and 20% use textbooks as eference material. In some cases the teachers read the textbooks together with the pupils, and in other cases the pupils read them on their own.

In the schools where the supply of textbooks is adequate pupils are allowed to take the books home. But in one or two schools belonging to the low performing category, the small supply of books that those schools have is considered so precious that no pupil is allowed to take them home.

Homework assignments

On average, 5 and 3 homework assignments are given per week by the high performing and low performing schools respectively.

The main source of homework questions shows a variation between the two categories of schools. For the high performing schools 80% of the teachers use past examination questions and 20% of them use improvised questions as the main source of homework assignments. For the low performing schools the main source of homework questions is textbooks (80%). The remaining 20% of the teachers use past examination questions.

On average the time spent on homework assignments for the low performing schools is 2.5 hours per week and 3.5 hours for the high performing schools.

Assessment procedure

When teachers were asked about the assessment procedure typically used in their grade 12 science classes, 80% of teachers in the high performing schools responded that the usual practice involved individual pupils completing tasks from the textbooks, and 20% indicated group work assessment as the main form of assessment. For the low performing schools 100% of the teachers claim that they use textbook exercises.

All the teachers indicated that they were the ones solely responsible for setting class tests. We also note that 80% of all the grade 12 science teachers sampled felt that the availability or otherwise of science learning materials did not affect the frequency with which class tests or assignments were given. But all of them did respond that the unavailability of certain science learning materials and facilities such as insufficient desks and teaching aids adversely affected various classroom learning conditions.

3.10 CLASSROOM OBSERVATION

As we have implied in earlier sections, the purpose of the study was to identify educationally valid and important ways in which the processes of teaching and learning grade 12 science are influenced by the availability, quality and use of a school's physical facilities and learning resources. What we considered `important' in the context is an influence likely to affect either pupil's learning opportunities and performance, or the degree to which teacher classroom effectiveness is enhanced or compromised

The task was an exploratory one in which we tried to identify types of relationships. It was clearly a matter of generating a hypothesis rather than testing it. Thus, we have attempted to observe what takes place within the confines of the classrooms in order to understand better the role of materials availability in the teaching learning process.

We looked at categories of patterns of classroom interactions using the following indicators, namely:

A. Group or individual activity	Pupils working by themselves with materials on problems set either by themselves or by the teacher. Discussions involving small groups that may include teacher.
B. Whole class discussion	A question and answer session involving the teacher and the whole class regardless of whether every child is participating or not.
C. Transition	Periods when teacher is handing out materials or rearranging pupils, etc.,
D. Teacher lecture	When teacher is talking to a class not in response to a question, and not requiring verbal answer from them.

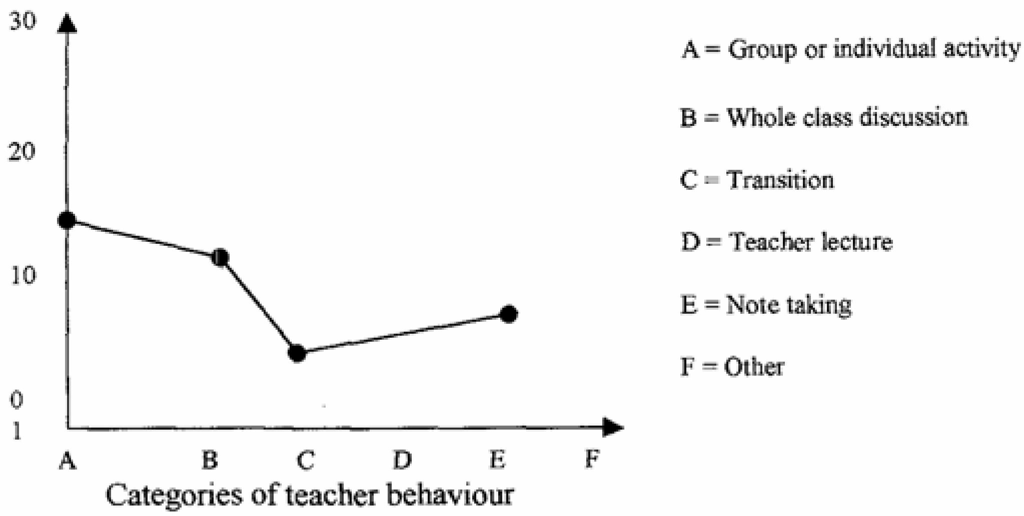
E. Teacher writes notes on chalkboard and pupils copy.

F.Other -whatever interaction that does not fit into any of these categories.

The teaching methods predominantly employed by the teachers in the science classes observed are illustrated in figures 1-3 as shown below.

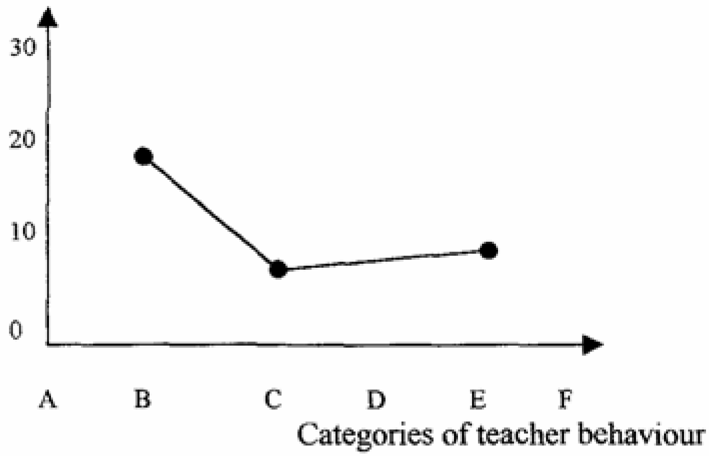
We found that on average the two schools that scored very high on the matriculation examinations and are reasonably well-resourced also scored high on pupil-centred classroom interaction patterns. Here, the teacher spent more time on pupils interacting with materials and discussion (see figs land 3). In the other example (fig. 2) which was the method consistently used by a majority of the teachers involved lecturing and use of textbooks, and pupils taking notes most of the time.

Fig. 1 Time vs Teacher behaviour categories



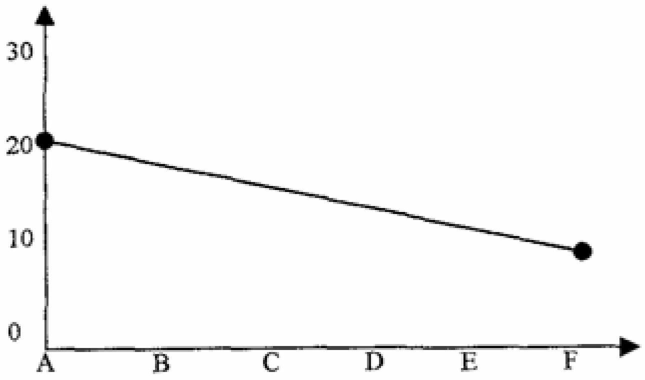
A = 13mins. B = 12mins. C = 4mins. E = 6mins.

Fig.2:



B = 18mins. C = 5mins. E = 7mins.

Fig.3



A=20mins. F = 10mins. (Teacher assist learners where they experience problems)

The most popular teaching methods observed e.g. fig.2 (see Appendix VI) engender passive learning and discourage participation by the pupils. For instance in 80% of the classes observed teachers used question and answer sessions, and 100% gave notes. Only 20% used either pupil question or individual/group activity.

Within the schools, we found that in the absence of instructional/learning materials or facilities, performance in schoot/classroom depended very much on the leadership and commitment of the headteacher, and the teacher. This relationship between teacher commitment, school governance and student performance was clearly manifested in the two top performing schools (schools A and B) with a respective 100 and 75 percent matriculation pass rate for 1996.

3.11 CLASSROOM PRACTICE AFFECTED BY MATERIALS AND PHYSICAL FACILITIES

Aspects of teaching affected by the quality and quantity of available materials and facilities were the extent to which teaching methods were pupil-centered, the variety of activities organized during lessons, the methods of communication used in lessons and the frequency with which assignments were given including their main sources.

Secondly, various other classroom conditions were affected, notably orderliness and ease of movement in the classroom/ laboratory; pupils' opportunities for working individually or in groups, and the time and effort required for teaching and learning activities to take place. We shall look at these groups of `dependent variables' as it were and identify the physical/materials input, which affected each in the classes observed

EFFECTS ON TEACHING PROCESS

We begin with the teaching variables. As far as the pupil-centred teaching methods used predominantly by the teachers(in two out of three observations) in the two high performing schools (schools A and B) are concerned, the evidence tends to support Hurst's view (1981, p.187) that `these *(pupil-centred* my italics) only yield more effective learning in the specially designed environment (rich in space, books and equipment) in which such methods can function properly.

The major observations are as stated: -

1. The extent to which methods were teacher-centred or pupil-centred was influenced strongly by the provision of science learning materials, pupils' textbooks, writing materials, exercise books and to a large extent by the provision of teaching aids, and furniture. Both classroom observation and the interviews with teachers showed that, wherever the pupils had no textbooks or inadequate science learning materials and equipment, lessons were characterised by oral exposition from the teacher most of the time, and by relatively slow comprehension and note taking on the part of the pupils.

2. When the schools are compared according to their performance categories, the number of distinct activities (e.g. oral exposition, note taking, exercise etc) during the lesson increases consistently as the provision of textbooks, instructional materials and furniture improves. In those schools (schools I and J) which had no pupil individual textbooks and inadequate science practical kits no lesson observed had more than one major activity. The data however do not enable us to compare the effects of different kinds of materials such as textbooks, desks that to a large extent were adequate or inadequate in the same schools. The availability of other teaching aids such as charts and models, teachers' study guides also affected the extent to which lessons called for active student participation.

3. In the school where pupils had to share textbooks it was difficult to prevent disorderly behaviour and one imagines that within the context of a large science class, teachers sometimes avoided using the textbook for this reason.

4. The variety of activities during lessons is a variable closely related to pupil self-activity and initiative. This, again, was strongly affected by the provision of learning materials and textbooks.

5. A third variable is the pattern of teacher -pupil interaction, which to some extent is related to the variety of methods of communication. As one might expect, the availability of audio-visual teaching aids, demonstration kits, pupils' writing materials, and textbooks affected the extent to which the teachers made use of visual and written messages in addition to spoken ones. Visual and `hands on' reinforcement of the teachers' spoken information was frequent in schools A and B whose stock of visual aids included models, science kits, educational cassettes, as well as charts and diagrams; occasional in schools, C, D and G, and rare in the other schools. Schools F, H, J and I had no commercially produced audio-visual teaching aid whatsoever.

6. Another aspect of teaching affected by materials availability or lack of them was, the source from which teachers set individual homework and class assignments. Frequency of pupils' home work was affected by the supply of textbooks and exercise books. Observations of lessons and pupils exercise books showed the giving of home work to be

frequent in schools A, C and E and occasional in schools F- H and relatively rare in schools I-J where textbooks and exercise books were sometimes not even available for sharing.

7. From the evidence of our lessons' observation, pupil attentiveness co-varied with discipline in class, with the variety of activities in the lesson, and also with ease of movement in the laboratory or classroom. By implication, it was affected by the provision of furniture, provision of teaching aids and the teacher's effective use of whatever learning material was available. Where desks were insufficient, you had the problem of overcrowding - which affected mainly the rural schools, schools I and J in particular, and difficulties were observed in writing exercises.

8. The interviews held with the teachers and head teachers did tend to confirm that their morale and indeed commitment to the profession was influenced by the physical condition and appearance of their school and science classroom as well.

9 The provision of opportunities for pupils to develop the process skills and useful methods of science such as measuring, observing, data interpretation, hypothesizing, experimenting, graphing etc was affected both by the process variables ofteaching approach/resources and time and independently by the available facilities. The high performing schools (schools A, B, and C) may have provided adequate opportunities, they had libraries, laboratories as well as adequate supply of textbooks, writing materials and science practical kits (see Table 2). Libraries are seen to encourage independent reading. But the low performing schools (schools H, I, and J) in particular, with their lack, of or scarcity of libraries, laboratories, writing materials and science practical kits did not provide adequate opportunities (see Table 2).

In concluding, as we have indicated earlier, the grade 12 science teachers observed were not altogether matched in experience and qualifications. It is therefore possible that teacher quality could account for some of the variations in teaching processes that we identified and described. Having said that, it needs to be pointed out that the relatively lack of variation within each school category (low and high performing schools) as well as the differences between school categories (high versus low performing schools) was striking to the researcher.

The findings illustrate the existence of multiple links between the availability , quality and use of school and classroom resources and a number of educational process variables which are widely considered as important determinants of student performance and quality of schooling. This evaluation applies more specifically in this study, to school facilities and learning resources, and teaching methods that allow and provide for active pupil participation in grade 12 science lessons.

To the extent that the process variables that we have identified can be assumed to affect measurable pupil performance, namely school science matriculation results, this study has thrown some light on the nature of the links between resource availability and use and pupils' achievement. Measuring the cause-effect relationship of kinds of resources on pupil achievement is beyond the scope of a small qualitative study such as this, but information was collected on various inputs, and the extent to which schools are delivering quality inputs was also examined.

The critical question for any education reform or policy initiative is the extent to which the findings lead to school-level improvement and benefit to pupils.

The findings suggest that perhaps previous `technical efficiency' studies have focused too much on the provision of single input- textbooks. It would be inefficient even in the most deprived economies to organize secondary science education without a systematic provision of laboratories, science instructional materials and qualified teaching personnel. Besides, government supply of pupils' other learning resources are desirable on the grounds of equity and redress.

Overall, the findings emphasize the fact that effective teaching and learning, of the kind expected in science classes, do require a technology. They show the need for more careful costing and allocation of resources within the education sector. Much broader debate, a stronger educational philosophical underpinning and political will to prosecute a well-funded science education programme at all levels with relevant stakeholders is called for.

CHAPTER FOUR

RECOMMENDATIONS

The following policy implications may be inferred from the findings of the study.

The variation in the quality and quantity of resources in schools surveyed gives rise to the following recommendations.

1. There is need to improve the equity of provision and distribution of educational materials and facilities in schools for the teaching and learning of science throughout the Province, especially in schools in rural locations. Science teachers should be evenly distributed so that they will not be concentrated in only a few schools while others lack experienced ones. Also, there is need for a policy of systematic monitoring and upgrading the standard of equipment, facilities and personnel for teaching of matriculation science.

2. There is need for a definite policy on the funding of science in secondary schools such that minimum standards (or financial provision) are set in terms of unit allocation per pupil.

3. The present low level of availability of science learning materials and equipment in many schools is such that we are in danger of producing a generation of students who are only familiar with textbook information and have no opportunity to engage in other science process skills development including manipulative skills.

   There is the need to design and develop alternate science examination syllabuses that reflect the reality on ground regarding resource availability, so that no one school is unduly disadvantaged in the attempt to follow set syllabuses.

4. The finding that the teaching of grade 12 science still tends to be traditional and devoid of some exciting innovations in teaching strategies in these subjects, makes necessary some definite policies in the training of teachers.

   Specifically, deliberate effort should be made to train teachers of science in

   (i) group and individual methods of working with pupils,
   (ii) keeping pupils purposefully occupied during science class so as to minimise disciplinary problems,
   (iii) greater use of improvisation and locally available scientific materials to generate practical activities and for visual aids,
   (iv) greater use of co-curricular activities such as excursions, field trips, science fairs and exhibitions,
   (v) greater and more efficient use of home work assignments and projects.

5. Well equipped laboratories enhance the teaching and learning of science subjects. Heads of schools and science departments should strive to maximize the use of existing laboratories in their schools. The provision of laboratories and laboratory equipment need

to be carefully planned and executed so as to effectively support the teaching of science. There is need for the Ministry responsible, to prepare a brochure on the standardization and specification of science equipment in secondary schools. The effort should also be extended to cover the specification of characteristics of laboratories such as floor space, unit-working space per pupil, minimum acceptable supply of water taps and sinks gas taps and electrical points.

6. The present low level of availability of and subscription to scientific journals in secondary schools is such that schools are in danger of producing a generation of science teachers and pupils who have textbooks as their major if not only source of information, and have no opportunity to broaden their understanding of science and its role in society . There is need for a definite policy geared towards a) increased subscription to good journals by schools, and b) diversification of available journals to, for example, promote greater popularization of science.

7. There is need for a policy on the minimum academic and professional qualification of science teachers handling matriculation classes. As of now lack of adequate number of academically qualified science teachers is a major constraint.

8. It is clear that performance in science, in secondary schools is dependent upon the primary school experiences of the pupils specifically in the development of (i) language skills, (ii) quantitative skills (iii) manipulative skills and (iv) three dimensional perception. There is need for a definite policy deliberately promoting the development of these skills at the primary school level.

9. Government should make or enforce policies on the minimum physical facilities and teaching resources in all schools at each level.

10. Promote a book policy, which would enable every pupil to buy textbooks at affordable prices. Pupils should be allowed to take science textbooks home.

11. Policies are necessary in respect of (a) Teacher supply (b) Quality of teachers in terms of academic and professional qualification, (c) teaching methods and (c) supply of equipment with a view to raising the standard of performance in science in the matriculation examination.

Particular attention needs to be paid to physical science which at present records the poorest performance.

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