An interim report on an investigation into modular Physical Science for Standards 9 and 10

An interim report on an investigation into modular Physical Science for Standards 9 and 10

D.J. Gray

Pretoria
Human Sciences Research Council
1988

D.J. Gray M.Sc., PGCE, Ac Dip Ed.

Institute for Educational Research
Executive Director: Dr. S.W.H. Engelbrecht

Printed and distributed by the HSRC
134 Pretorius Street
Pretoria

FOREWORD

It is intended that this project paper should be used as a working document by all interested parties concerned with science education. Any comments and evaluations of the concepts proposed here would be gratefully received.

The Institute for Educational Research feels, very sincerely, that an effective means of improving the status and quality of science taught in South African schools is through a national discussion forum based on working documents such as this and, through which a purposeful consensus can be arrived at.

Throughout this report careful attention has been paid to the recommendations of the Human Science Research Council's Investigation into Education of 1981. Moreover a way has been developed for a more harmonious communication and co-operation between schools, technikons and universities, on the one hand, and commerce and industry on the other to educate the youth of South Africa in a way in which all parties are intended to benefit.

The stress in this document is on the concept of modular Physical Science and its management and implementation and the proposals are based upon what is hoped are acceptable definitions and philosophies. It is NOT intended, at this stage, to permit this proposal to become obscured by discussions on curriculum content and the finer details of modular titles and structures. A proposal with regard to module content will be produced for consideration at a later stage. The essence of this proposal is its flexibility and its capacity to meet changing community needs and perhaps for this reason alone it is worthy of consideration.

Dr S.W.H. Engelbrecht
Executive Director

CONTENTS

****

TABLES AND DIAGRAMS

****

EKSERP

Dat die standaard van wetenskaponderwys in Suid-Afrikaanse hoërskole deur die handel, nywerheid en universiteite as onbevredigend beskou word, word algemeen aanvaar.

Die bestek en omvang van bestaande probleme in die wetenskaponderwys word in hierdie werkstuk aangespreek en 'n Natuur- en Skeikundekurrikulum wat op modules berus, word voorgestel - 'n kurrikulum wat sal bydra tot die oplossing van sommige van hierdie geïdentifiseerde probleme en terselfdertyd ook verskeie voordele sal bied.

Alhoewel daar min in die vorm van gevestigde fondamente is om op voort te bou en ook nog nie 'n volledig ontwikkelde filosofie ter ondersteuning van die modulêre stelsel gebied kan word nie, dwing die wydverspreide neiging na en belangstelling in modulêre onderrig oorsee ondersoek van hierdie konsep af.

In hierdie werkstuk word voorgestel dat Natuur- en Skeikunde volgens 'n verkennende loodsontwerp onderrig en geëvalueer sal word en dat die gewone skooleindsertifikaat of universiteitsvrystellingsertifikaat by voltooiing van hierdie modulêre program uitgereik sal word. Verkryging van bogenoemde sertifikate sal afhang van die voltooide modules wat stelselmatig tot sy/haar 'krediet' by elke leerling se rekord gevoeg word. Die Natuur- en Skeikundekurrikulum word onderverdeel in 'n 'kern' van Fundamentele Modules (die volstrekte minimum wetenskapkennis wat as basis vir verdere onderrig in die vak aanvaarbaar sou wees) en 'n reeks Akademiese (gegrond op teorie) en Toegepaste (praktykgerigte) modules waaruit voldoende krediete versamel kan word met die oog op verwerwing van 'n skooleindsertifikaat gelykwaardig aan die huidige stelsel van 'n tweejaarkursus met 'n finale eindeksamen.

Waar die Akademiese modules steeds by die tradisionele onderverdeling in Natuur- en Skeikunde sal aansluit en wat tema en inhoud betref sterk teoreties van aard sal wees, sal die Toegepaste modules meer verband hou met relevante wetenskap d.i. dié wetenskap wat skoliere daagliks in hul algemene lewenswandel teëkom asook dit wat die grondslag vorm van Suid-Afrikaanse industriële vervaardiging.

Die voorstel dat praktiserende onderwysers betrokke sal wees by die skryf van voorgeskrewe modulehandboekies is van deurslaggewende belang in hierdie voorstel vir modulêre wetenskaponderwys. Onderwysers sal ook self deelneem aan 'n noukeurig beplande indiensopleidingstelsel wat weer die program aan ander onderwysers sal bekendstel.

Dit is nodig om weer eens te beklemtoon dat hierdie voorstel vir modulêre onderwys as alternatief tot die bestaande tweejaar Natuur- en Skeikundekursus aangebied word en dat die geleentheid geskep moet word vir hierdie stelsel om parallel met die bestaande stelsel te kan groei en ontwikkel.

ABSTRACT

It is generally accepted that existing opinion in commerce, industry and universities is that the standard of science education in South African secondary schools is not satisfactory.

This discussion paper outlines the scope and range of existing problems in science education and proposes that a modular based Physical Science curriculum would contribute to solving some of the identified problems and carry with it numerous advantages.

Whilst there is little in the way of established foundations and no developed philosophy to support a modular system of instruction the widespread trends into modular instruction in many overseas countries makes the concept worthy of investigation.

It is proposed that Physical Science be taught and assessed in a pilot scheme, with the commonly accepted School Leaving Certificate and Matriculation Exemption Certificate being granted, on this modular programme, each completed module being 'credited' to the pupil's record once it is assessed. The Physical Science curriculum is divided into a 'core' of Fundamental modules (the absolute minimum science upon which to base further science instruction) and a range of Academic (theory based) and Applied (issue based) modules from which sufficient 'credits' can be accumulated for the pupil to obtain a school leaving certificate equivalent to the existing system of a two year course with a final examination.

Whilst the academic modules should relate to the traditional sub-divisions within Physics and Chemistry and have a sound theoretical theme and content, the Applied modules should relate more to relevant science, i.e. the science that school pupils come into contact with in their everyday lives and the basis of South Africa's industrial production.

Critical to this modular science proposal is the suggestion that practising teachers should be involved in the writing of the module books and participate in a carefully planned inservice training system to familiarize other teachers with the programme.

It should be stressed that this modular proposal is offered as an alternative to the existing two year Physical Science course and that it should be allowed to grow and run parallel to the existing system.

THE CONCEPT OF MODULAR PHYSICAL SCIENCE FOR STANDARDS 9 AND 10.

> "It is, in fact, nothing short of a miracle that the modern methods of instruction have not yet entirely strangled the holy curiosity of enquiry."
>
> Einstein

1 INTRODUCTORY REMARKS

The aim of this report is to present, in broad outline, the need for change in the present science education system in South Africa; specifically a change to a modular system. The intentions and effects of modularization and the management of problems likely to be associated with such an implementation are examined. Whilst the main thrust of this document is directed towards Physical Science, there is no reason to suppose that the underlying philosophy, reasons and proposed methodology cannot be transferred, in broad outline, to other subjects. These could include Mathematics, Biology, Geography, First Language and the technical subjects. The intention of this report is to focus on Physical Science and to consider the implications of restructuring the teaching and learning opportunities in this subject if the subject is to be approached in a modular manner. Since the school leaving certificate is such a contentious and critical issue in South African science education today, the stress has been laid upon an alternative curriculum structure for the final two years of secondary education, i.e. Standards 9 and 10. Standard 8 Physical Science has not been ignored but is discussed only briefly.

2 A STATEMENT OF THE PROBLEM

2.1 THE DIVERSITY OF DEMANDS MADE ON THE SCIENCE CURRICULUM

Considerable thought has been given, by various authors (for example as listed in Garbers *et al.* 1985), to identifying general and unique problems that beset the South African science educational situation. It cannot be claimed that, individually, any of these factors are unique to this country but in combination they present a barrier both to education and to social development that may not be replicated anywhere else in the developing countries of the world.

The issue at hand becomes: Why propose an alternative to the existing Physical Science curricula and offer an alternative route to a school leaving certificate?

The history of journal articles recording discontent with the state of science teaching in South African schools is extensive. Science Education has been the focus of numerous enquiries and investigations from several different perspectives. (Drost 1983, Van Schalkwyk 1981, Jansen 1979, 1982 and 1983, Swanepoel 1982 and the HSRC Investigation into Education (1981), to name the HSRC enquiries alone.) It is apparent that both the admission requirements of the universities and the expectations of the general pupil with non-scientific aspirations are not being served adequately by the present provision in South African schools. Conjectures, (e.g. the unattractiveness of teaching as a career choice (HSRC 1981, (1) 4.5.3 (iii) p.67)), theories, (e.g. the supply of adequately qualified teachers (HSRC 1981, (1)3.5.2.2(b) p.65) and facts (e.g. the falling numbers of first degrees taken in the sciences (HSRC 1981, (1) 2.3.4 p.25)) relating to identified shortcomings, are well documented (HSRC 1981). One possible way out of this dilemma is to examine alternative ways of teaching Physical Science which may be more acceptable to both the universities and to the school pupils who study science. Examination of the present curriculum structures suggests that structure is as much at fault as content in the present situation.

2.2 PROBLEMS COMMON TO THE WIDER SCOPE OF EDUCATION

2.2.1 Interrupted schooling

The factor of interrupted schooling, for what ever reason, for example medical absence, temporary lack of teachers, and school boycotts, are different aspects of another problem in South African education. The possibility of school closures, for example, militates strongly against any two year linear curriculum being taught successfully. During any prolonged 'stayaway', school pupils incur serious disadvantages which cannot be adequately remedied in the established linear curriculum and academic year. This problem, in cases where considerably less than the two years of teaching time has been available presents an almost insuperable barrier for the student. (DET and News Reports suggest in some cases that this was as low as 60% of the available time for some schools in 1985.)

2.2.2 Final examination

The total dependence of the results of two years of education on an 'all or nothing' examination exerts a strongly negative motivation on students.

2.2.3 Formal and non-formal education liason

The lack of mobility between formal and non-formal institutions and the lack of communications between the technikons and the schools contribute appreciably to the problems in science education. (HSRC report - The Training of Artisans , 1985)

2.2.4 Flexibility

The lack of facility for a rapid response and rapid revision of current science curricula to newly perceived demands from industry and society, more generally can be considered as a serious curriculum shortcoming in a rapidly changing society. The last major revision of the Standard 9 and 10 Physical Science syllabus took place in 1967. This syllabus subsequently underwent numerous revisions, mostly as the removal of minor topics and since them there has been one larger scale revision and restructuring that became effective in 1986/7.
(The present revision period can be regarded as being in the order of 20 years, whereas in Scotland the time from the

conception of a scheme to its first implementation is nearer to 3 years, and for revisions this is reduced, in many cases, (e.g. SCOTVEC modules) to as little as one year). This raises the question - is it possible for a linear or spiral curriculum to be amenable to frequent revision and restructuring? This represents more than an administrative and decision making problem. There are financial implications in prescribing new texts, trials, and training which also contribute towards extended delays and reluctance to embark on curriculum revisions.

2.3 PROBLEMS MORE SPECIFIC TO SCIENCE EDUCATION

2.3.1 Relevant science

The lack of relevant science in the existing academically based syllabusses is an effective deterrent to many students considering science studies. School leavers who are members of the South African community need an education which will enable them to offer useful skills and knowledge on the open job market. (SAATPS 1978.)

2.3.2 In-service training

Personal experience and communications with numerous teachers suggests that an appreciable proportion of in-service courses for teachers fail to relate to the subject matter that is being taught at any given time in schools. Topic specific courses often either precede, by too long a time, or post date the classroom programme. Certainly, in some education departments orientation and training courses are too few in number. This lack of timeous training would appear to reduce the value of such courses whereas a training based on a modular curriculum would help to negate this deficiency (See section 14 below).

2.3.3 Science and technology students

The failure to attract school pupils, in sufficiently high numbers, into Physical Science courses at school can be attributed to many reasons, not the least of which would be the present curriculum, content and structure. The data below concerning matriculation candidates and the proportion, for the whole of South Africa, who offer Natural Sciences at Higher Grade is worthy of consideration:

TABLE 1

THE NUMBERS OF STANDARD 10 PUPILS STUDYING THE NATURAL SCIENCES - IN 1984.

Department	Number of Standard 10 pupils in 1984.			
	Total pupils in Std.10	Total studying Nat.Sci.	Studying Nat.Sci. %	
White education (1)	56 718	13 366	23,6	-
Indian education (2)	10 830	2 438	22,5	-
Coloured education (3)	14 688	2 989	20,3	-
Dept. Ed & Tr.(4) RESULTS	18 146	3 019	16,7	Pass 392 % Pass 13,0
National States (4) RESULTS	39 895	5 224	13,1	Pass 579 % Pass 11,1
TOTALS	140 277	27 036	19,3	

Sources:

1. Central Statistical Services : Education - Whites, 1984
2. Central Statistical Services : Education - Indian, 1984
3. Central Statistical Services : Education - Coloured, 1984
4. Department of Education and Training: Annual Report, 1985.

These data indicate that less than 20% of South African matriculants offer Physical Science at Higher Grade. This is before any consideration is given to the pass/fail ratio, which as it can be seen, in the case of the DET and National State schools approximates to a pass rate of one in eight. (It should be acknowledged that the pass rate for the other departments will be considerably higher though.) By extrapolation then, this failure to provide sufficient incentive, through school foundation courses in the sciences, for students to study the 'hard sciences' at universities and technikons represents a contributory factor to South Africa's economic dilemma. The manpower supply shortages in scientific and technical fields is considerable. The Associated Scientific and Technical Societies (AS&TS) assessment (1984) in Kelvin House News on the supply of engineers is supported by the 1987 claim of an Engineering Company executive who stated that the ESKOM staffing requirements for Heavy Current Electrical Engineers for 1988 would be 100 engineers. In 1987 the total number of university graduates in this field from all South African universities was to be twenty seven i.e. a shortfall of eighty three, for one industry alone (Collins 1987). This shortfall is likely to be reflected in many other scientific and applied science fields.

2.3.4 Scientific literacy

The 1986-1987 revised science syllabusses reveal an absence of many aspects of science and technology which ought to be regarded as crucial to minimum levels of scientific literacy in school leavers. (Syllabus analysis - Joint Matriculation Board (JMB) and Transvaal Education Department (TED) 1986) For example -

1. There is no mention of economically important industries such

as ISCOR, SASOL and ALUSAF, or of the electrolytic process.
2. There is no reference to the particle accelerator in the Cape.
3. There are no references to the mining industry.
4. There is little mention of alternating current electricity.

2.3.5 Science in South Africa

The absence of all but brief mentions of "Science in South Africa" cannot be regarded as improving the local self image of the scientific professions. The revised JMB physical science syllabus referred to above (1985/6) and for implementation in 1986/87 has comparatively little science content which relates to South African science, technology and industry. This is contrary to the trends in several overseas countries. See for example the Criteria for Science education in the United Kingdom and numerous journal articles such as those by Zoller (1985), Hecht (1986), Curry and Holman (1986) and Black (1986) to mention but a few (Syllabus analysis - JMB and TED, 1986).

2.3.6 Science curriculum expectations

The widely divergent expectations from a single science curriculum in terms of pupil ability levels (Higher Grade/Standard Grade), pupil career intentions (scientifically based/non-scientific) and employer/tertiary education requirements (educated as opposed to trained) are not being efficiently catered for in the single strand science curriculum that is taught at present (HSRC Investigation into Education, 1981).

2.3.7 Academic content of syllabuses

A key criticism of virtually all our present subject syllabuses is that the design and content seems to be based (perhaps unconsciously) on the ideal that each subject is preparing the pupils for a professional career in that subject - hence the overlying academic and highly structured approach to these subjects.

The changes that became effective in 1986 were greeted in some quarters (notably the chemistry department at the University of Natal - Laing 1986) with enthusiasm. However, closer examination suggests that whilst the revisions are more than 'cosmetic changes', there is still an overburden of academic theory and a lack of relevant science and no movement towards integrated subject matter. Similarly, at least two of the largest education departments have taken no advantage of the 'optional topic' dispensation introduced for standard 9 in 1986. (Optional topics were originally proposed in <u>A Science Education Policy for South Africa</u> - 1978.)

2.4 SUMMATION OF THE PROBLEMS

Consideration of these factors leads to the conclusion that science education must continue in its present parlous state with periodic marginal changes and revisions, or that substantially different proposals should be given serious consideration so that the necessity for improved science education is acknowledged.

The model upon which existing and previous Physical Science curricula have been based is highlighted in 2.3.7 above. Little or no consideration, save as an afterthought, appears to have been given, to other than academic expectations. Certainly the overt criticisms of science curricula have persisted for many years and reached a peak with the publication of the HSRC Investigation into Education (1981). The response to this document, insofar as syllabus content was concerned, was a low key change (already mentioned) in the 1986 syllabus of some academic content for some applied content with South African connotations. (JMB 1985) The philosophy underlying this newest Physical Science curriculum can only be interpreted from the rubric and stated aims and objectives. However, from these it can be surmised that few aspects of 'science in action' or of Science as an 'active' verb were considered. The list of identified problems above inevitably raises the question: What were the causes and how can they be remedied?

The causative factors, as in all cases dealing with human elements, are complex and numerous. The HSRC report (1981)on education highlights many of them. For example:
(i) the distribution of science curriculum control between the various education departments (Investigation into Education - Vol. 6, p.34),
(ii) the over centralization of power and the process of decision making (Investigation into Education - Vol. 1, p.38),
(iii) the falling social status of teaching as a profession and vocation (Investigation into Education - Vol.1, 4.5.3,iii, p.67),
(iv) the falling proportions of students studying the 'hard sciences' (Investigation into Education - Vol.12, p.17) , and
(v) the poor qualifications, lack of initiative and basic skills of existing teachers (Investigation into Education - Vol. 12, p. 60).

In essence this proposal suggests that a modular curriculum could contribute appreciably towards solving some of the short and medium term problems that beset science education in its South African context.

3 WHAT ARE MODULAR PROGRAMMES?

3.1 THE FOUNDATIONS OF MODULES

An extensive search through available literature on curriculum development has revealed very little that refers to the philosophy or fundamentals of modularization of any school subject. Titcombe (1983) speculates that modular programmes may have their origins in the 'Object Lessons' of the early nineteenth century schools in England. The lack of a philosophy underpinning modular theory is supported by the Digest with Education (1986) in which an unnamed author states: 'There is as yet no literature making a theoretical case for a modular approach to the secondary curriculum'. Those who have made changes to a modular programme, to quote Prof. W.A. Gatherer (1987), have done so 'because it works'. It has not been possible to find a widely used and acceptable definition of what is regarded as a module. There are, however, numerous references to MODULAR or UNIT schemes for teaching many of the conventional school subjects.

For the purposes of introducing modules to this report a module can be regarded as a complete teaching package on a defined topic that should be taught in a specified time and is intended for final assessment at the end of that teaching programme and the pupil's record credited with the outcome. (The definition is expanded upon in section 7.1.) A modular programme, or curriculum would consist of a series of modules taught one after the other.

3.2 A BRIEF STATEMENT OF THIS PROPOSAL

It is proposed that Physical Science should be taught and assessed on a modular basis in Standards 9 and 10. (An extended definition of modules and the types of modules is set out in section 7.1 and 7.2.)

Modular Physical Science should be offered as an <u>alternative</u> system of gaining a School Leaving Certificate, with Matriculation Exemption where applicable. This modular system would be in contrast to the present two year curriculum which terminates with a final examination and, in some cases, an internally assessed contribution.

In this proposal a modular curriculum would consist of a group of 'core' compulsory modules supported by a series of more or less independent modules. The 'core' modules would be regarded as non-negotiable but the intention is that the optional modules should offer at least some range of choice, preferably to be made in the individual school. The 'core' modules would consist of what could be regarded as the fundamental principles of Physics and Chemistry whilst the optional component would deal with other key scientific fields and applications of science in the South African context.

As will be demonstrated later in this report modular systems are established in many countries and indeed many sectors of the overall South African educational system have already transferred, or are in the process of transferring to modular schemes (the group training centres, some technikon courses and the Building Industries Federation for example). It may be germaine at this early stage to summarize the details of the main differences between the existing two year curriculum and the proposed modular scheme and to elaborate upon the details of the proposed alternative at a later stage.

3.3 A COMPARISON BETWEEN THE TWO YEAR SCIENCE PROGRAMME AND A MODULAR PROGRAMME

TWO YEAR CURRICULUM	A MODULAR CURRICULUM
1. Two years in duration	1. Duration of each module can be determined by the topic.
2. Single terminal course assessment.	2. Assessment of each module or any acceptable combination of modules.
3. Inflexibility to change and revision on grounds of cost, retraining and administrative commitment	3. Wholly flexible and far less costly to revise or replace as determined by new needs and expectations. i.e. a modular curriculum can be customized.
4. Dependent on long term goals - i.e. a two year programme.	4. Short term goals and reinforcement, short time lapses before feed back of individual module results.

A COMPARISON BETWEEN THE TWO YEAR SCIENCE PROGRAMME AND A MODULAR PROGRAMME (continued)

5. Rigid academic structure in both the Higher Grade and the Standard Grade syllabuses.	5. Courses can be adjusted to suit individual classes and their needs.
6. Centralized decisions on content and sequencing of content - with the present 'blanket' application of new curricula to all schools little in the way of trials and evaluations are possible before implementation.	6. Trials, evaluation, and in-service training are all readily implemented on a modular basis. Teacher written teaching materials can be used.
7. Relatively little teacher contribution to the curriculum.	7. Scope for teacher contribution and participation.
8. In the event of pupil failure for any reason whatsoever a whole year must be repeated.	8. In the event of a poor result a single module can be repeated at a time suitable to the pupil.
9. There is no provision for accelerated or slower than the group learning.	9. Provision for accelerated and/or even post school completion of a modular course would be manageable.

4 THE SEQUENCE OF THIS APPROACH TO A NEW SCIENCE CURRICULUM

Factors or criteria that should be considered when developing a new curriculum for Physical Science fall into four main groupings. An attempt has been made, within the limits set by these criteria, to derive a scheme that conforms to South African needs and the problems identified. The sequence of factors that have been considered for developing a new curriculum for Physical Science can be grouped as follows:

(i) A situation analysis that involves an examination of the origins of the problems that have been identified in science education in South Africa.
(Section 2 - above)

(ii) An examination of the systems operating in other countries. This requires an assessment of what components of these systems can be applied to the South African context. (Section 5 - below)

(iii) An application of the aims, objectives and goals and a philosophy of science education that is determined by the parameters of national, social and economic needs and expectations.
(Section 6 - below)

(iv) The format of various established curriculum patterns that are available should be examined to justify this proposal. The curriculum modes that have been examined are:

a) <u>The linear curriculum</u> - which has a clearly defined beginning and progresses to a defined end. There may be some expectations of knowledge of foundation work covered in earlier years of schooling. This is descriptive of the system that operates in South African schools at present in Standards 9 and 10.

b) <u>The spiral curriculum</u> - in which various topics in an essentially linear structure are revisited at intervals and treated in greater sophistication and depth. The present relationship between several topics in Standard 8 on the one hand and Standard 9/10 syllabuses on the other show a spiral revisitation. The basic assumption though is still a continuous scheme of work with a final assessment at the end of a year.

c) ' Core + options ' - in this structure the 'core' material is treated as being essential and a variable optional programme can be attached to this core. Effectively this possibility for curriculum design has been refined into the proposal set out below in sections 3 and 12.

d) Unit courses - or in American terminology, modular courses may consist of unrelated and unlinked topics of variable duration that are taught during an academic year. Many of these courses appear to lack in continuity and what could be termed 'scientific culture'.

e) Module courses - as described below are derived from the 'core + options' format but which relates both to the SCOTVEC and to the New South Wales systems described briefly below (5.1.6 and 5.1.7). This format allows for interrupted schooling, built-in teacher training, interchangeability between educational institutions and provides opportunity for flexibility in the curriculum that appears to be lacking at present.

5 SYSTEMS OF SCIENCE EDUCATION IN OTHER COUNTRIES THAT MAY HAVE SOME RELEVANCE TO A MODULAR SCIENCE PROPOSAL FOR SOUTH AFRICA.

Before any recommendations can be made, an examination of systems in other selected countries is necessary to give some insight into the trends in science education elsewhere and identify those criteria and practices which may be of value in South Africa.

5.1 SUGGESTED GUIDELINES FROM MODULAR CURRICULA OUTSIDE SOUTH AFRICA

Bearing in mind the identified problems and the stated expectations of a Physical Science curriculum a basis for the proposals that follow can be derived. The options made have been based to a large extent upon existing educational programmes from:

(i) England, based on the University of York modular scheme,
(ii) Australia, using the 3/4 Unit science course of New South Wales as a pattern, and
(iii) the Scottish SCOTVEC modular system which is so effective that it should be taken into consideration in the design of any new teaching system which hopes to ease the existing problems in South African science education.

It must be stressed that this modular proposal is NOT at any stage intended to supplant or replace 'in toto' the existing two year Physical Science programme. The intention is that an alternative means of qualifying for entry into tertiary education and providing school leavers with a useful education experience in science be offered.

5.1.1 The United Kingdom

The new Northern Examinations Association (NEA) offers a modular science course to O-level (1985). This course is based on a two year course with a final examination that is combined with a contributary assessment from the school. (Mode II assessment)

(Note : Mode I assessment is an examination wholly based on an externally set and marked examination. e.g. the Joint Matriculation Board examinations.
Mode II assessment is based on an externally set and marked examination combined with a contributory record mark from the school. e.g. The Transvaal Education Department School Leaving Certificate.
Mode III is an assessment for certification carried out wholly within the school. e.g.The Transvaal Education Department Project Schools were assessed on a slightly modified Mode III basis.)

5.1.2 The new General Certificate of Education

The new General Certificate of Secondary Education (GCSE) has recognized no less than 14 science syllabuses (British Council Course 629 - Dr F. Garforth, 1986), two of which are modular. This variety caters for the diverse needs of student ability, and local scientific activities and needs. All the GCSE syllabuses MUST, since 1986, meet the conditions laid out in the National Criteria for Science Education (1986) - such criteria have not been defined for application within South Africa. These criteria are referred to later in this report (section 6.6).

It cannot be proposed that a variety of courses, similar to the GCSE offering, or that 'pure' subject Physics and Chemistry could be offered in this country at present. Even in the United Kingdom there is a rapidly decreasing number of teacher trainees in the sciences and widespread discussion about the shortage of qualified Physics teachers is leading toward a consideration that Physics should be withdrawn from the curriculum in some schools. (Times Educational Supplement - October 1986)

5.1.3 Salter's chemistry from the University of York

This chemistry course, developed by the University of York, and financed by private enterprise and trust funds, has been approved by the new GCSE in the United Kingdom. Thus this course has already met the conditions laid out in the Criteria for Science Education, set out in paragraph 6.6 of this report.

Salter's chemistry is designed around 'what children know and find interesting' rather than the traditional approach of 'what they need to know'. This in no way reduces the educational value of the course but it does imply new and radically different approaches to subject content and in some cases a different list of priorities within topics.

The whole two year course is built up of 14 units or modules, each based upon some fundamental area of natural curiosity or interest for the pupils. The lay out of the Salter's units incorporates extensive teacher guidance and management procedures which could be of considerable use if applied in a South African setting. Details of assessment processes and methods are also included.

The key issues that South Africa could learn from in the development of Salter's Chemistry are - firstly the materials were compiled and written by practicing teachers (Salters' Project 1985 p.3). Secondly the method of financing from outside the formal education system is what was envisaged by the Human Sciences Research Council's 'Investigation into Education' recommendations (HSRC 1981 12, 5.1.2 f, pp. 91-92). This pattern has been taken up in this Modular Science proposal. Most importantly - Salter's Chemistry was extensively trialled within schools with departmental approval as well as being supported by the Examination Boards. Trials and subsequent modifications have been identified clearly as being essential to any pilot scheme in modular science particularly. This last point was underlined in the HSRC Investigation into Education, Volume 12, p. 49 which refers to the inadequacy of the current syllabus development methods.

5.1.4 LAMP Modules

Other English experiences in modular education are aimed almost exclusively at the lower ability range (e.g. the East Anglian schools (1982) modular schemes and the LAMP project work (ASE 1976)). This, to some extent has given modular education a bad name in the science education community in the United Kingdom, insofar as higher ability students and the wider public are concerned.

5.1.5 Israel

The Science Education Institute in the Weitzman Institute in Israel has produced several excellent units or modules based on their realm of domestic scientific activity. e.g. 'Life from the

Dead Sea' by Avi Hofstein et al . (1984) The move, away from translated versions of Chemstudy was the result of a growing Israeli awareness that local science is intrinsically more important and in the long run more valuable to the students. It is certainly envisaged that the modular science in this proposal would match this Israeli move towards 'local' context science. With reference to 'credits' and examinations, which will be referred to later in Section 21, an article by Tamir (1988) is worth noting. Tamir describes the Israeli examination system thus:

'In the mid-seventies [in Israel] a much more flexible system was established. Each subject is now offered in 3 or 4 levels, designated by credit points ranging from 2 to 5 points. To be eligible for a matriculation certificate, a pupil has to accumulate at least 22 points.'

5.1.6 Australia - New South Wales

The New South Wales Board of Senior School Studies (1984) has produced a series of syllabus handbooks which are both admirable in their planning and concept as well as containing much from which South African science education could benefit. The 3/4 Unit Science course is designed as a series of options built around a core of compulsory material. This 'core' is the basic 2 unit course that all students should study during their last two years of schooling. Since this is a general science course the core contains elements of physics, chemistry and biology and, what is notably lacking in South Africa, a component of geology. The geology component has been taken up briefly in the modular proposal that follows.

The core is planned to occupy roughly half of the two year course. As optional subject courses linked to this core there are two-unit (roughly just less than a full matric subject) pure subject courses in biology, chemistry, physics and geology and integrated science. Each of these courses is in turn divided into a core plus a series of options. The options giving the teachers and the pupils scope to pursue courses that bear the most relevence to them. This relationship between core and options and 'pure' subject possibilities is set out in the following two diagrams (see over the page). In the main proposal of this document the 'core' plus options has been modified somewhat to allow for both differences in ability and differences in interests to be catered for. The key advantage of the New South Wales system is that it provides sufficient flexibility for the individual pupil to engage in science studies at a depth at which he or she requires it, i.e. as a preparation to further study, as a supportive course to studies in other fields or just as part of a general educational background.

Table 2

NEW SOUTH WALES - THE RELATIONSHIP BETWEEN CORE AND OPTIONS

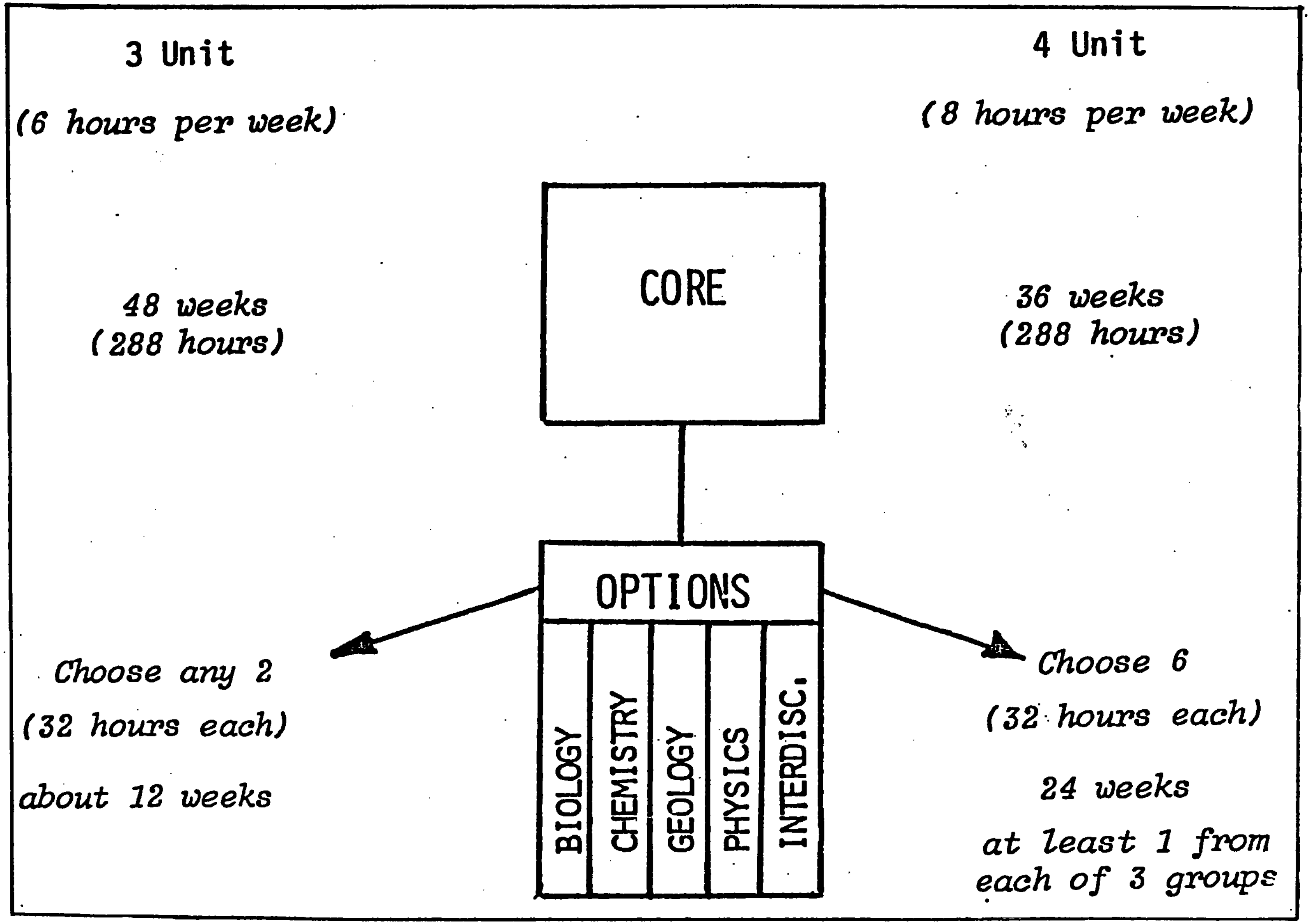
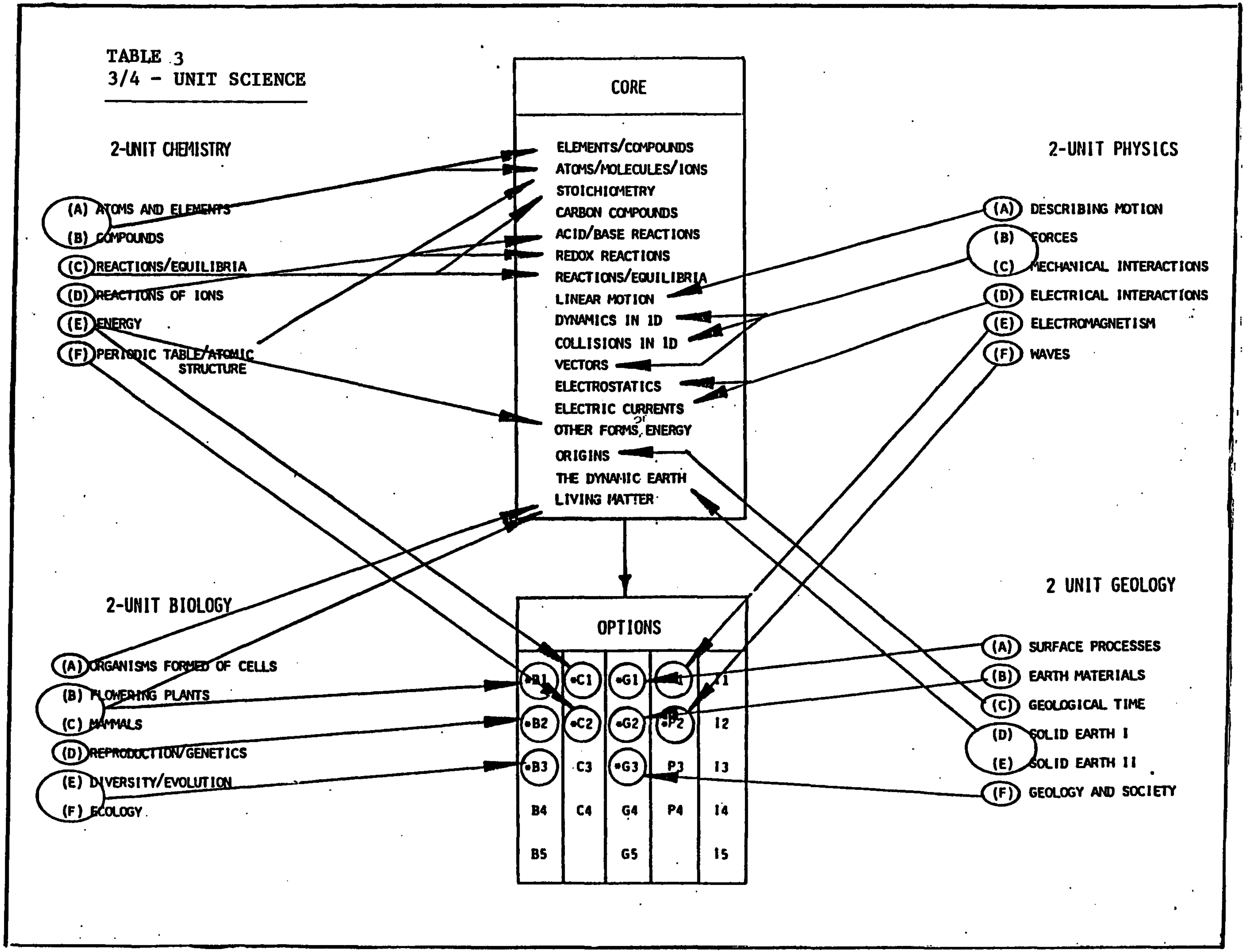


Table 3

NEW SOUTH WALES - THE STRUCTURE OF THE CORE-OPTIONS RANGE IN 3/4 UNIT SCIENCE COURSE



5.1.7 Scotland - SCOTVEC

Under the auspices of SCOTVEC (The Scottish Council for Technical and Vocational Education) there is a powerful and expanding modular education system that could exercise compelling attractions for the education departments of South Africa. SCOTVEC is primarily concerned with technical and vocational education but is spreading rapidly to encompass the more conventional school subjects. The duration of a SCOTVEC module is set at 40 hours instruction time. The SCOTVEC modular system is being offered, to an increasing extent in schools as well as technical colleges, colleges of further education and through the medium of private education as well as through distance education. SCOTVEC modules are also being developed for the more conventional school subjects. More importantly, from a South African point of view, credited modules are recognised by the whole range of tertiary institutions (further education and universities) and by employers for entrance qualifications. An advantage of the SCOTVEC system is that individualized courses can be designed for identifiable small group requirements (e.g. a single employer) by the selection of agreed or suitable clusters of modules. The Scottish National Technical Certificate does set out certain specified module requirements for their qualifications.

The provision of SCOTVEC module descriptors as the sole teacher guide cannot be regarded as sufficient for the South African teacher, who in many cases may be underqualified. Thus, this proposal contains the suggestion that modular texts, for both the teacher and the pupil be written by groups representative of teachers, tertiary education and industry. As in the SCOTVEC Guidance and Support Services, the teacher's module text should provide advice and guidance on teaching methods, experimental management, assessment advice and sample questions. A check list of required or expected competencies should also be provided for each module as happens in the case of the SCOTVEC module descriptors (see Appendix 1).

The SCOTVEC system retains a negotiable component within the content of each recognized course, which can be seen as a highly admirable approach to studies in Physical Science - since negotiated modules can be used to reflect the needs of smaller groups of students than the whole national school going populations in Standards 9 and 10 (e.g. locally important industries and scientific activities).

On a similar basis SCOTVEC certification provides each student with a clear statement of modules completed in a particular year or in a particular course of study. It was felt that this 'feedback' of educational status to the student was valuable and could be best instituted in this country in the form of a modular receipt as amplified in paragraph 12.2.

[Additional advantages could be obtained by a closer examination of the Scottish Sixth Year schooling. Like South Africa, the Scottish school system is based on a five year secondary cycle for university entrance qualification. Many of their students attend school for a sixth year in which they prepare for the English A-level examinations or for the Scottish Certificate of Sixth Year Studies. This extra year permits applications to be made to the English universities and optimizes applications for highly competitive faculties in the Scottish universities. Consideration could be given to expanding the modular system into all or part of a sixth year in specialist fields.]

The systems outlined very briefly above (5.1.1 to 5.1.7) collectively contain potential solutions for some of the problems identified in science education in this country, but a judicious combination of compatible components from several systems might well provide a remedy for many of these problems.

6. APPLICATION OF SOUTH AFRICAN AIMS, OBJECTIVES AND GOALS TO SCIENCE EDUCATION.

Curricula do not have a happy history of transplant from one country to another. Therefore it becomes a fundamental precept that South Africa must look to its own solutions to its own educational problems, taking note of experiences, methods and trends in other countries.

6.1 THE NEED FOR NATIONAL CRITERIA FOR SCIENCE EDUCATION

There is an urgent need for commonly accepted national criteria for science education. These should not necessarily follow the example of England and Wales where criteria for science education list the aims, goals, administrative processes, assessment systems, the teaching methods and to some extent the practical content of different syllabuses. This move, in the United Kingdom, can be seen as a method of moving towards some common norms and standards between the various examining bodies. A South African statement of national criteria would achieve similar ends but additionally these could give the whole of science education a sense of direction and purpose other than 'examinations and certification'. Syllabuses should to be seen to apply stated Aims, Objectives and Goals rather than to pay lip service to them. In section 13, below, there are proposals based on the criteria that have been developed in the United Kingdom.

6.2 SCIENTIFIC LITERACY SHOULD BE A PRIMARY OBJECTIVE IN SCHOOL SCIENCE

The need for an acceptable level of 'scientific literacy' is stated and defined in section 6.6.2. This aim should be regarded as one of the most fundamental outcomes of the science educational experiences in our schools. This aim has been met to some extent in other countries by the inclusion of science in the compulsory 'core' curriculum up to the minimum school leaving age (e.g. in the United Kingdom the intention is that some science will be studied by ALL pupils up to the age of 16). The problem of what to include and what to exclude from such a 'compulsory core' curriculum (the 'nul' curriculum approach outlined by Flinders _et al_ , (1986) needs serious attention). Science should be regarded as an obligatory component of the 'core' school curriculum up to and including Standard 8 and its content and approach should be clearly distinguishable from the Science taught in Standards 9 and 10, where it should become an optional or elective subject.

The entry of 'applicable science' and 'interdisciplinary science' are well established trends in many countries, the UK, Israel, Singapore, Australia, and Brazil to name but a few. These trends however, are not without their opponents. In the U K there is a developing policy that integrated science should be 'the order of the day' up to O-level for as many students as possible, i.e. the 'pure sciences are being de-emphasised up to O-level. There are no planned changes for the A-level university entrance single subject courses. An examination of the arguments presented in The Structure of the Curriculum (Scottish Department of Education - 1977, p. 30), suggests that 'subject based' education may continue to be preferable to, and more manageable than, 'integrated' education. However, this should not absolve 'science' education from the obligation of establishing links and common bases with other scientific fields and industrial activities. Imaginative curriculum structuring would satisfy both the needs of problem solving approaches and many of the other criticisms made by the proponents of 'integrated education'.

A further consideration that must be borne in mind is that science is only one subject component of a greater school curriculum - it is essential that single subject changes should be compatible with and co-ordinated with other subjects in the curriculum, e.g. (i) any Science curriculum plan should incorporate a clear statement of the mathematics expectations at each stage of that curriculum, and (ii) there should be an acknowledgement of criteria common to the different subjects.

6.3 THE DEVELOPMENT OF A MULTIFACETED CURRICULUM BASED UPON A PRAGMATIC OR ESSENTIALIST APPROACH

"PRAGMATISM - A philosophical movement holding that practical consequences are the criterion of knowledge, meaning and value" (Collins Dictionary 1986)

When constructing curriculum guidelines for science teaching in a developing nation, one inevitably faces the question - can a country facing overwhelming scientific and technical requirements afford the 'luxury' and financial extravagance of idealism? Can South Africa continue to afford to educate one generation after another of school-going pupils within a framework designed for the comparatively small proportion who will go to university? Particularly with the added limitation that less than 25% (J.M.B. report of 1984) of candidates offer Physical Science for examination at school leaving certificate level (this is before a failure rate is considered) and considerably fewer will study in scientific fields. There can be no simple solution but it would appear logical that in situations of great need and of limited resources a pragmatic or essentialist (Hearne and Cowles 1988) approach should be a priority. This pragmatic prescription is not necessarily in conflict with the contributions that can be extracted from 'idealist' thinkers (such as Adler 1982) but their aims should be rationalized to be effective in view of local priorities. The problem facing aspirant curriculum developers is elegantly posed by Tuthill and Ashton (1983) :

"Educational scientists are divided over whether the goal of educational science is to develop theories or to improve practice."

The aims of curriculum theory tend to be polarized into extremes, and illustrative of one of these extremes are Kerlinger (1973) and the Paideia Group - the theorists:

(i) Kerlinger : "The purpose of scientific research is theory ... Scientific research never has the purpose of solving human or social problems, making decisions, and taking action... He [or she] should never be required to think about or spell out the educational implications of what he [or she] is doing or has done." and,

(ii) Adler (of the Paideia Group) : "Those forces [either commercial or industrial interests or any interests outside the cloistered corridors of the educational world] must not be allowed to intrude into the school and determine what quality of education will be dispensed to which groups of children. By insisting that all children can achieve a 'rich and satisfactory intellectual experience in education' Paideia argues for a greater equality than is present in either education or society now ...." (Quoted by Dennis Gray (1985) An old humanist's reply to Appel - Curriculum Inquiry , 15, 1985, pp.319-323)

(This philosophy is reflected in the attitudes of many of the British Public Schools and 'upper class' local authority schools. Any possible encroachment of technology or industry into the educational system is vigorously shunned. This explains, to some extent, the slow adoption of Technical and Vocational Educational Initiative (TVEI), as well as Integrated Sciences in United Kingdom schools.)

At the other extreme of attitudes towards the aim of research Scriven (1980), the practitioner, advocates that:

"Improved practice is the goal of educational research".

The phrases, 'improved practice' and 'good practice' are particularly current in the U.K. at present and serve to cover a multitude of aspects of education ranging from classroom technique to curriculum structure and teaching philosophy. In the long run though, it would seem that 'good practice' comes back to a 'democratic' instinct for what is right rather than a rigorously defined structure or methodology.

Eisner (1979) formulated an attitude towards education that allows a pragmatic basis to be established without the attendant risks of dogma :

"What we can productively ask of a set of ideas is not whether it is really true but whether it is useful, whether it allows one to do one's work more effectively."

This approach suggests that a curriculum should not be too closely linked to any one particular curriculum paradigm. Too close an adherance restrains flexibility and style of response. A curriculum can be structured so that it contains (inherently) the possibility for revision of ideas (content) and sets out the option for a 'paradigmatic shift'. Kuhn (1982) refers to a state of 'crisis' that can develop when currently held paradigms become untenable. It is argued that such a state exists now in science education. The deduction is then - that a curriculum based upon a pragmatic paradigm would possess response flexibility. This should perhaps be a major factor in the policy of curriculum development for the immediate future planning.

From an absolutist stance James (1948) states that : "Pragmatism is based on the belief that those ideas or actions that work the best are true, whereas all others are false."

A modification of James' statement leads to the concept that the truth can only have a limited existence in terms of 'time and situation'. In a pragmatically structured curriculum there must be the belief that it can be replaced, all or in part, as time , changing social situations, priorities and circumstances warrant. Supporting this concept of self-correctability Feyerabend (1978) states :

"No decisions [curriculum models] are absolute, nor are any ideas [curriculum philosophy] perfect. All truths [curriculum models] must be subject to constant review, reanalysis and change [in the light of current circumstances]."

The argument developed here to explain the background to this modular proposal, is summarized by Hearne and Cowles (1988):

"Within the Transmission model, however, there exists a division of thought - the Perenialist and the Essentialist views of education...

Essentialism, on the other hand, proceeds under the rather utilitarian notion that "if it works then it is good". Essentialists advocate the transmission of "essential" things that a mature adult needs to know to be a productive member of society. The focus is on pragmatics and scientific approach."

With a nearly 20 year interval between the last two Physical Science curriculum revisions and refurbishments (HSRC - Investigation into Education, Vol. 12, p.31) flexibility has patently not been an option in South African education. (Present South African curriculum design is firmly in the Perrenialist mode - "... they feel that the real substance remains unchanged over generations." (Hearne and Cowles 1988))

It is the consensus of this report that it is no longer tenable to maintain that a developing nation can support an educational practice based on a rigidly structured academic paradigm. In so many African countries this would appear to be part of the postcolonial heritage that they are only now beginning to discard. A mechanism should be found to run trials on new and experimental curricula for what can be regarded as the implementable constituents of 'good practice'.

Traditionally, in South Africa, technical or applied education has had a very low esteem ranking by parents, pupils, teachers and administrators, and yet the training that the Technikons and Technical schools are beginning to offer (which is becoming increasingly modular) is what industry needs from its recruits. The question that arises then is - can a developing nation afford the indulgence of such ideals as are postulated by the Paedeia Group and similar educational theoreticians? The academic and administrative educational communities have had both the time and the experience to have developed their 'practice' beyond Socratic debate (and hemlock?) to resolve practical problems. Whilst conceding the many potential hazards of educational experiments - their results MUST be more satisfactory than either a maintenance of the 'status quo' or the institution of new policies and curricula founded upon discussions of rigid educational paradigms enunciated in committee rooms!

This report, therefore, is a proposal that Physical Science should be taught and assessed in a modular format. It is proposed that such a format would offer the possibility of remedying many of the known shortcomings of science instruction in this country. Furthermore, Ackerman (Transvaal Educational News - November 1985) has indicated that several of the education departments have entered into modular studies of their own accord, but only on premises determined by their existing syllabuses and administrative establishment. It is thought that an independent inquiry into modularization, free from these constraints and free from preconceived ideas, may have a greater validity.

6.4 PROVISION FOR THE NEEDS OF THE 'END USERS' OF A SCIENCE CURRICULUM

It should be remembered that the pupil is not the only party with needs and expectations from his/her science education. There are national, social and employer expectations that also need to be considered in science curriculum development. The establishment of common national aims, objectives and goals, mentioned earlier, as well as population norms and standards are important issues. If a rationale for the modularization of school science is attempted then it must be conformable with the scholastic and social needs of this country. Furthermore, within the South African context and perhaps more generally, a curriculum is doing neither the learner nor the subject justice if the attitudes of the learners are not influenced in such a way as to optimize the enrollment in school science courses and in tertiary science education. On the same basis, a competent curriculum will provide the nation with an educated and informed populace with some of the skills required for them to live reasonably comfortably in an increasingly technical world. Informed voters and consumers (i.e. scientifically literate school leavers, see section 6.2) is one of the aims against which the success of a curriculum should be measured, as well as being a recruiting basis for national technical and scientific manpower requirements.

Any new curriculum must include, as a fundamental requirement, opportunities for the development of the professional skills and learning opportunities for teachers. This should not be based exclusively upon the needs of the most poorly qualified teachers and thereby restrict those teachers with greater initiative, professional commitment and higher skills. A modular system can be designed to meet both the requirements of a wide range of pupil abilities and expectations as well as a wide spread of teacher qualifications and skills.

In the final analysis any curriculum innovation becomes a matter of weighing the advantages, in this case, the modularizing of Physical Science, against the apparent disadvantages. On this basis it can be confidently expected that each of South Africa's diverse communities will attach different weightings to the criteria that are to be considered.

6.5 GOALS OF A CURRICULUM

6.5.1 Curriculum innovation

"It would be foolish to consider the possibility that any one system or curriculum would be appropriate to all countries, or to expect traditional and established methods to be swept aside quickly. Any attempt to enforce one system upon all would be equally wrong. Circumstances must affect the choice of approach, but it is useful to compare systems and extract the best features of each so that they can be taken into consideration where they are most appropriate, and to experiment with new ideas and methods."
(Educational Technology in the Teaching of Chemistry. IUPAC Inaugural speech by Professor Sir Harold Thompson, President IUPAC p.viii, 1975.)

In confirmation of Thompson's comment above, the record of CHEMSTUDY, the NUFFIELD SCIENCES and numerous other examples of major curriculum innovations suggest strongly that curricula do not transplant easily from one country or culture to another. Indeed, one of the major problems encountered by the Nuffield Foundation was that the 'Nuffield Philosophy' did not transfer to a large proportion of UK science teachers. Particularly those who were not intimately concerned with the development of Nuffield material.

A speculation that arises from the United Kingdom experiences with the Nuffield Science courses is that:

- one of the possible reasons for curriculum failure could be that, whereas the planners have a total committment to the innovation, the 'average' teacher in the classroom, is in a situation where the innovation can affect only a portion of his or her particular timetable. Thus there is a lower level of commitment to the innovation and extraneous pressures that the designers are not subject to.

This places a great obligation on South Africa to seek its own solutions to the problems of science education in this country and to the extent with which teachers become burdened with changes. Careful attention should be given to the variety of options and the knowledge gained in other countries. An overview of the current curriculum changes in a few developed and developing communities has already been made (see Paragraph 5 above) and guidance has been taken from their experiences.

A critical point in the assessment of science education came in 1983 when a prominent South African scientist declared :

> "Even if South Africa entered an economic boom cycle - we would miss it because of the drastic shortage of manpower in the technical and scientific fields." (Tobias - 1983)

The diagnosis of an educational problem has been made. What of therapy and prognosis?

Jansen (1985) formulated a definition for a curriculum as being:

> ' 'n Kurrikulum is 'n plan of program vir onderrig-leer wat gekonseptualeer is in die lig van sekere doelstellings en waarin minstens geselekteerde en geordende inhoude opgeneem is'
>
> [... a programme for teaching and learning which is conceptualized in the light of certain goals, aims and objectives and which contains at least selected and sequenced content (author's own translation)]

This definition can be sub-divided to make allowance for the traditional school subject divisions. Thus the curriculum of Physical Science as a subject will have to consider

* the goals, aims and objectives of Physical Science;
* the selection and sequencing of the formal content of learning material from the Physical Sciences, and
* structured learning opportunities in Physical Science teaching in formal and non-formal situations.

Thus a modular Physical Science curriculum would have to meet

* the demands of Physical Science as a discipline;
* the needs of the learners, and
* the demands and needs of a wider South African society.

6.5.2 Short and long term goals, aims and objectives .

Bearing Jansen's definition in mind and being aware of the developments in the new GCSE in England it would be beneficial to approach the goals and aims of Science teaching through a formal statement of "CRITERIA FOR SCIENCE EDUCATION" (Department of Education and Science 1985) as has been done in England. This at least would serve to establish a common ground for Science education bearing in mind the cultural, economic and political differences between the United Kingdom and South Africa that must be considered and despite the emphasis placed by the GCSE on grade criteria assessment and the inclusion of a practical work component that may not be possible in South Africa.

Reading the preambles and rubrics to various South African syllabuses suggests that many of the overall aims and objectives are drawn from the realms of philosophy or are far removed from the practical considerations of day to day classroom practice and individual teachers. This gives rise to the consideration that there should be a regrouping of listed goals, aims and objectives into

(i) more generally stated conditions and aims that cover the tenor of a teacher's classroom approach to the subject. This point is philosophically important, since there seems little to be gained by enumerating aims and objectives which are not implementable by the hypothetical 'average' teacher. These aims and objectives could and should be part of basic teacher training. However, these more 'global' aims must temper the teacher's classroom manner and approach to the subject, (e.g. scientific honesty may not be suitable in a day to day situation, as a listed aim, objective or goal, but it most certainly should be reflected in a teacher's conduct of experiments, the processing of data and in his/her dealings with pupils, i.e. Criteria for Science Education).

(ii) aims and objectives of the whole science curriculum in overview. These would include the range of expected skills, competencies and knowledge to be gained by the pupil, i.e. the skills of the 'educated' pupil.

(iii) shorter term and clearly implementable aims and objectives for teaching and learning opportunities for each module and within each module.

6.6 THE NEED FOR SCIENCE EDUCATION AND LITERACY IN SOUTH AFRICA.

6.6.1 National criteria for science education

There is a need for an acceptable statement of national criteria for Science education which must of necessity be a consensus document and the following, modified slightly from the Criteria for Chemistry applied in England (1986), should only be considered as a possible starting point for further discussions. Proposed criteria for Science education should be intended :

(i) to stimulate students and create and sustain their interest in, and the enjoyment of Physical Science;

(ii) to provide a body of scientific knowledge appropriate for students
- a) to encourage further studies in science;
- b) who will not study the subject further;
- c) to establish an awareness of the inter-disciplinary links between the various fields of scientific endeavour;

(iii) to promote in students an acquisition of knowledge and understanding of scientific patterns and principles;

(iv) to encourage students to apply their scientific knowledge and under-standing to familiar and unfamiliar situations and,
- a) to make students aware of the importance of scientific method;
- b) wherever possible to develop students' abilities to perform experiments;
- c) to illustrate and to encourage the

development of students' abilities to form hypotheses and design experiments to test these hypotheses;

(v) to encourage the development of students' abilities to interpret, organize and evaluate data in order to make decisions and solve problems;

(vi) to develop students' abilities to communicate in appropriate ways;

(vii) to encourage students to appreciate the developing, and sometimes transitory nature of scientific knowledge, principles and models;

(viii) to develop students' appreciation of the scientific, social, economic, environmental and technological contributions, applications and implications of science.

It is necessary to expand upon the intentions of these criteria with particular reference to the goal of scientific literacy in school leavers.

A priority aim of science education must lie in the objective of some minimum of scientific literacy for all school leavers. Scientific literacy in students may be described as a stage when they, the students, have sufficient scientific understanding to regard an increasingly technological world as being "user friendly" and to be able to make informed decisions on matters of social concern.

A more elaborate statement of the expectations of "scientific and technological" literacy has been developed by the American National Science Teachers Association (NASTA -Technological literacy and the science curriculum. Curriculum conference, New Jersey Science Supervisors Association, March 27 1985, pp. 20-21)

6.6.2 Scientific literacy

"A [scientifically] and technologically literate person

- uses science concepts, process skills and values in making responsible everyday decisions.

- understands how society influences science and technology as well as how science and technology influences society.

- understands that society controls science and technology through the allocation of resources.

- recognizes the limitations as well as the usefulness of science and technology in advancing human welfare.

- knows the major concepts, hypotheses and theories of science and is able to use them.

- appreciates science and technology for the intellectual stimulus they provide.

- understands that the generation of scientific knowledge depends upon the inquiry process and upon conceptual theories.

- distinguishes between scientific evidence and personal opinion.

- recognizes the origin of science and understands that scientific knowledge is tentative and subject to change as evidence accumulates.

- understands the applications of technology and the decisions entailed in the use of technology.

- has sufficient knowledge and experience to appreciate the worthiness of research and technological development.

- has a richer and more exciting view of the world as the result of science education.

- knows reliable sources of scientific and technological information and uses these sources in the process of decision making." (NASTA 1985)

On review, the British National Criteria for Chemistry and the NSTA expectations of a scientifically literate person are in many ways concordant. This is, of course, as it should be, if the two views have a common basis.

Equally, any South African science curriculum development must be designed around the necessity for built-in teacher training and up-grading opportunities. With such a large part of South Africa's population still technologically semi-literate (see definition in 6.6.2 above), teacher training and re-training, needs to be integrated into curriculum development - not appended to, or superimposed on, the main stream of the science curriculum.

6.7 THE SUBJECT CONTENT OF PHYSICAL SCIENCE

The actual content of a Physical Science curriculum is yet another potentially divisive issue. Purists already have valid reservations about the linking together of Physics and Chemistry into a single subject. Many teachers accept the amalgamation but have reservations about the 'single subject' value of Physical Science as a pre-university training as opposed to the possibility (as does exist in the New South Wales system) of a 'double subject' weighting, i.e. twice the teaching time, increased content and more rigorous examinations supported by practical examinations and twice the contribution to the final School Leaving Certificate aggregate. Whatever proposals are made there are sure to be objections and reservations, particularly since the Physical Science offered in South Africa at present is intended to be 'all things to all men', i.e. there are no real distinctions made for the varying needs of the different pupil 'end users' of our science education, whether they are tertiary science and technology or 'fine arts' orientated. There are several parameters that can be established with some degree of certainty though.

After due consideration of criteria for science education and factors relating to scientific literacy a Physical Science curriculum for South Africa could be built upon a basis that the science taught in the last two years of schooling should represent:

* a corpus of knowledge taken from the disciplines of Physics and Chemistry. This corpus should also consider the needs of more interdisciplinary studies;

* a corpus of knowledge which is structured, organized and sequenced to meet the ability of the pupils and which is meaningful and relevant to the society in which they live;

* a corpus of knowledge which can be related to, and takes cognizance of non-formal educational opportunities and of the other school subjects;

* an educational programme which is responsive to the diagnosed problems of our present educational programme and which will possibly alleviate some of these problems, and

* an educational programme which considers the concept development level of the pupils at all stages of the curriculum and which is flexible and can be adjusted to the pupil's needs and intellectual development.

7 A PROPOSED TERMINOLOGY FOR MODULAR SCIENCE

It would perhaps be clearer at this stage to define a modular proposal in fairly extended form and then to examine the various merits and demerits of this proposal.

[Note that these comments relate directly to Physical Science, but with modification they could be made to apply to most school subjects.]

7.1 DEFINITIONS OF MODULES AS APPLIED TO THIS PROPOSAL

[Since word values vary considerably from country to country and from culture to culture and even from person to person it is necessary that the terms to be used should be defined to avoid misunderstanding.]

One statement of what a module is comes from W. Robert Houston (1972) in the book Competency-based Teacher Education - Progress, Problems and Prospects . His definition is as follows:

The 'instructional module' includes a set of activities intended to facilitate the learner's achievement of a specific objective or set of objectives. It is a relatively self-contained unit, designed for a specific purpose, and is a part of a broader, more comprehensive instructional system.

Thus most modules include five parts:
i. The RATIONALE. This is a clear statement explaining the importance of the content or theme of the module and relevance of the objectives to be achieved.
ii. The OBJECTIVES are stated in criterion referenced terms.
iii. A PRE-ASSESSMENT which tests the learner's competence in selected prerequisites and evaluates his present competence in meeting the objectives of the module.

iv. The ENABLING ACTIVITIES which specify several procedures for attaining the competence specified by the module objectives.

v. The POST-ASSESSMENT, like the pre-assessment, measures competency in meeting the module objectives.

Houston's statement has been modified to derive a definition for the more limited field of Physical Science modules in the context of this report and would subdivide into the following components:

> A PHYSICAL SCIENCE MODULE IS A BODY OF KNOWLEDGE AND TEACHING MATERIALS COMPILED ON A SOUND THEORETICAL BASE BEARING IN MIND THE NEEDS OF THE TEACHERS, PUPILS AND A MORE GENERAL SOCIETY. A PHYSICAL SCIENCE MODULE SHOULD HAVE ITS AIMS, OBJECTIVES AND DURATION CLEARLY STATED IN A PREAMBLE AND SHOULD HAVE A CLOSELY LINKED ASSESSMENT PROCESS AS PART OF IT.

These Physical Science modules should all have a common format and presentation and integrated teacher training materials so as to provide maximum assistance where it is needed.

7.2 TYPES OF MODULES

In this proposal it is envisaged that modules should be of two types:

1. FUNDAMENTAL MODULES - These are modules embodying what is generally regarded as the theoretical foundations of Science without which further education in the subject cannot proceed in any meaningful manner. Fundamental modules should contain a required minimum subject matter for all ability levels but the rigor of treatment could perhaps take ability levels into account.

(The number of modules specified as being fundamental could be determined by the National Certification Council and/or the individual Education Departments.)

2. NON-FUNDAMENTAL MODULES - These are modules dependent only upon fundamental modules for previous instruction and no other input for their effective classroom use. Non-fundamental modules would cover topic areas or issues that school leavers should generally be expected to be familiar with but will not be educationally disadvantaged without exposure to them.

(Efforts should be made to incorporate interdisciplinary links within these non-fundamental modules and to relate them to the everyday life of the student and the everyday activity of the nation. (See Criteria for Science Education - ii. and viii. in section 6.6.1). In this way students will not see science as a strictly compartmentalized body of knowledge nor as an academic exercise without any relationship or value to real life.)

Within the compass of non-fundamental modules there should be two divisions, designed to a large extent, with the end user - the pupil - in mind.

ACADEMIC MODULES should have a stronger theoretical base but should still acknowledge the implications of the content to the social and economic realities of society. Academic modules should have CENTRAL THEMES relating to the main stream of scientific thinking and scientific structure. In the main the intention in these modules is to provide a basis for those pupils intending to enter further education in a scientific field.

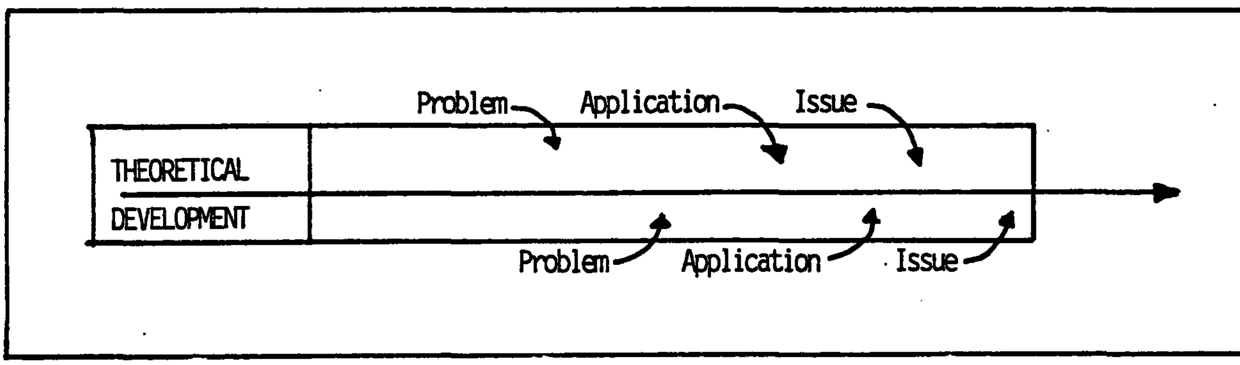
APPLIED MODULES should relate more closely to the realities of student lives and the society that they will become part of after their formal education is completed. A principal expectation from these modules would be to enhance scientific literacy in school leavers.

7.3 THEORY AND APPLICATION BASED MODULES

The principal distinctions between academic and applied module content should be the manner in which they are constructed, the pupil ability range at which they are aimed, and pupil needs and intentions with regard to further education in science. (This outline has been modified from a presentation by Holman 1986)

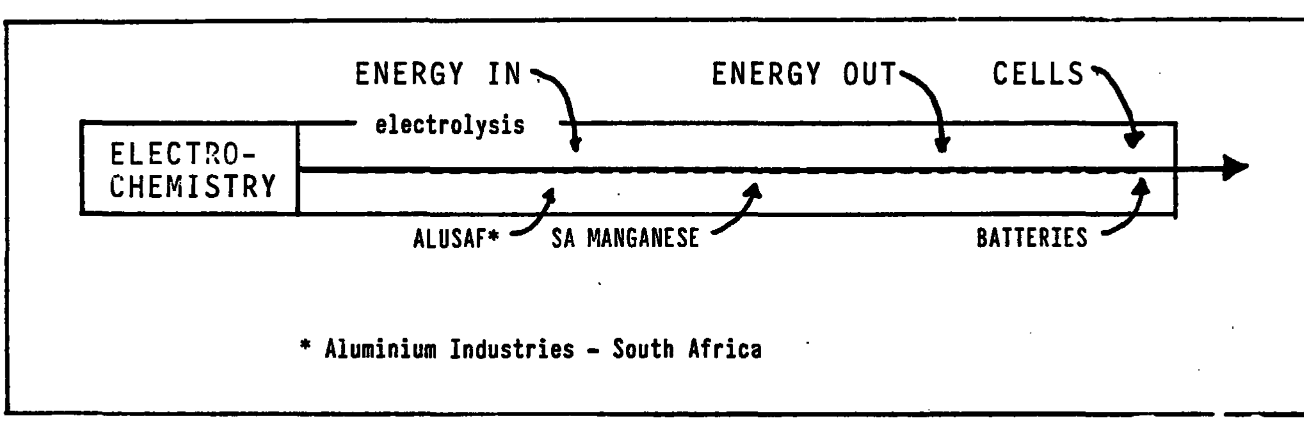
ACADEMIC MODULES - should be theory based with an introduction of problems, issues and applications wherever necessary. This is more clearly shown in diagram form thus:

TABLE 4 - ACADEMIC MODULES



For example -

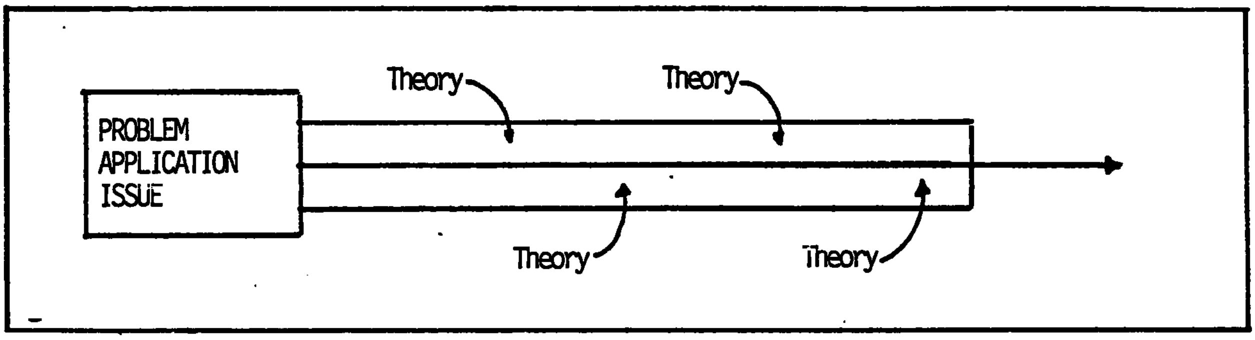
TABLE 5 - AN EXAMPLE OF AN ACADEMIC MODULE



These modules would be intended to be a foundation for tertiary education in a scientific field.

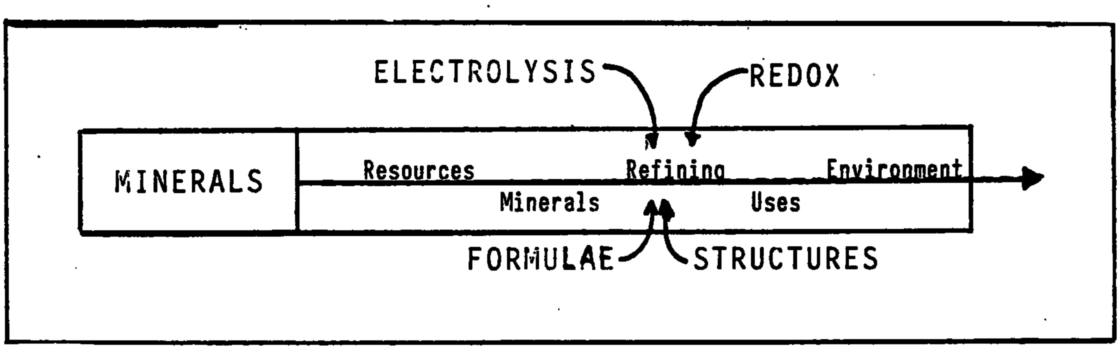
APPLIED MODULES - should be problem or issue based with an introduction of theory where ever it can serve to elucidate the problem, issue or theme. In diagrammatic form thus :

TABLE 6 - APPLIED MODULE



For example -

TABLE 7 - AN EXAMPLE OF AN APPLIED MODULE



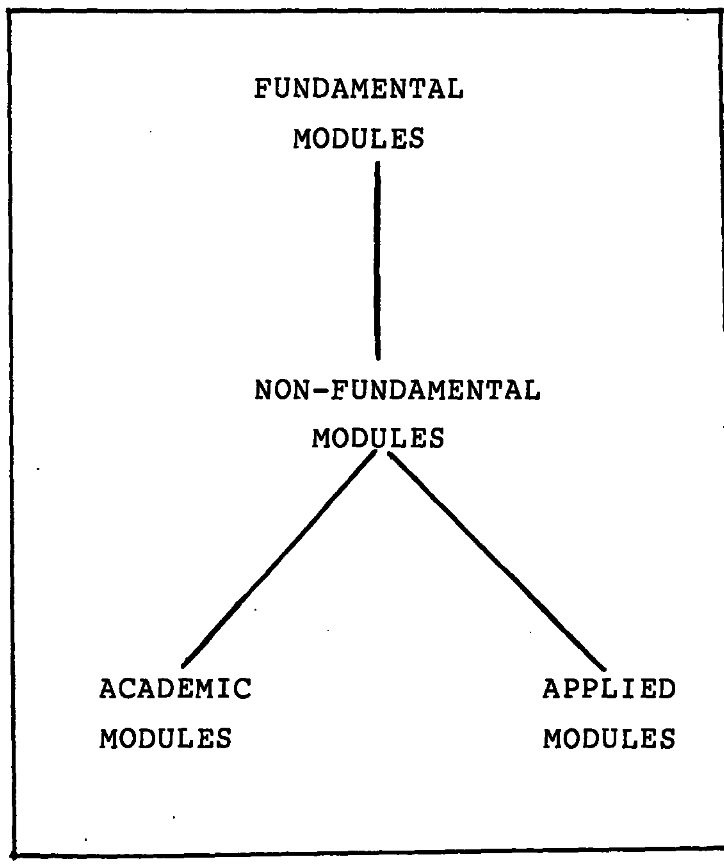
These modules would be directed, both in cognitive expectations and content, to those pupils who do not intend entering a scientific field after completing their schooling.

7.4 THE RELATIONSHIP BETWEEN THE DIFFERENT TYPES OF MODULES

In tabular form the relationship between the proposed types of modules can be represented thus :

<u>TABLE 8</u> : THE RELATIONSHIP BETWEEN THE DIFFERENT TYPES OF MODULES

<u>SUBJECT</u>
<u>PHYSICAL SCIENCE</u>



The structure of the fundamental modules should be determined by the topic and could relate to the structure of either that of the academic or of the applied modules.

PROPOSAL It is proposed that a core of fundamental modules plus combinations of non-fundamental (academic and applied) modules replace the present higher and standard grades in horizontal structuring. The extent and nature of the 'core' should be determined jointly by the National Certification Council and the executive education department. This presents the possibility that some pupils could study the fundamental 'core' plus a mostly academic modular course. Those less inclined towards a carreer in the pure sciences could follow courses made up of the fundamental modules plus a composite of academic and applied modules. Those pupils inclined towards non-scientific careers would be taught the fundamental modules and entirely applied modular programme with the underlying intention of basic scientific literacy. At the present stage of development, no provision has been made for the lower grade pupils in this proposal.

The status distinction that exists between Higher Grade and Standard Grade would then be dispensed with.

7.5 A PROPOSED FORMAT FOR MODULE DESCRIPTORS AND MODULE STRUCTURES

There is a workable and previously tested format available for application to new materials in the University of York - Salter's Chemistry and a University of York M.Sc. thesis on Optional Topics (Gray 1986). This scheme of presentation would adapt very well to in-service training schemes and for classroom use.

There are many advantages to the production of modular teaching and class materials in a uniform format. During the compilation of a module, the content and approach should be continuously compared with the "CRITERIA FOR SCIENCE EDUCATION" and with other specified shorter term aims and objectives. The SCOTVEC - Descriptor (Appendix A) as a precursor to the actual writing of texts and handbooks has many advantages. This method would ensure a clear description of aims and objectives and expected learning outcomes ahead of the writing process, thus providing a check on content, approach and method.

7.6 COMPILATION OF MODULAR MATERIALS.

This is a critical issue. The Scottish Vocational Educational Council (SCOTVEC), which operates a modular descriptor system and relies on teachers to convert the descriptor into actual teaching materials, is experiencing serious problems with teacher's unions and withdrawal of services. The argument is that the compilation of materials is a form of unpaid labour. In addition one of the key recommendations of the Human Sciences Research Council's Investigation into Education was for an increasing business and industrial commitment to and investment in education. Bearing these two points in mind, SEE 7.7 and 7.8.

7.7 THE FINANCING OF MODULE DEVELOPMENT

It is proposed that the authoring of module materials should be on a paid commission basis. The commissioning fees should be raised in industry and paid, on contract, to writing groups. (The writing of these modules is not a one person operation - they must be the product of collaboration.)

7.8 AUTHORING

Individual 'crystal' teachers of recognized talent should be contracted to assemble a writing team and to produce material ready for classroom trials in an approved format. In addition to practising teachers , wherever possible, a writing team should also have representation from universities, technikons, one or more of the participating education departments and from Industry on it. Considerable thought has been given to scales of fees but no concrete recommendations are offered. At present this is in the realm of speculation.

7.9 MODULAR DESCRIPTORS

The SCOTVEC descriptors have a three to five page structure which is sub-divided in the following way, (some modifications have been added to suit local conditions) :

1. MODULE TITLE AND NUMBER

2. TYPE OF MODULE

3. AUTHORING GROUP AND INSTITUTIONAL REPRESENTATIVES

4. PREFERRED PRECURSOR MODULES (only a prerequisite for a few cases and interdisciplinary required knowledge)

5. LEARNING OUTCOMES - these should be specified in some detail.

6. CONTENT AND CONTEXT - the actual scope of the module and the intended approaches.

7. MINIMUM EXPECTED PRACTICAL WORK - demonstration and class work

8. ENRICHMENT AND EXTENSION WORK - particularly practical work for the better equipped schools - suggested resources for expansion of the module topic.

9. SUGGESTED LEARNING AND TEACHING METHODS AND APPROACHES

10. ASSESSMENT PROCEDURES - This should include a requirement for at least 60 objective type questions - multiple choice and others - all to be carefully matched against the listed expected learning outcomes. Other guidance for pupil assessment should also be outlined.

11. REFERENCES AND RESOURCES - This should list references, industries, audio-visual aids and other information likely to be of use to the writers and eventually to the teachers.

* * * * *

7.1Ø A MODULE FORMAT

Each module would have two separate requirements,

* a Teacher's Guide and,

* a Pupils Book.

The materials should present information that is close to a lesson by lesson layout with a sequenced order of presentation and resources for each section.

7.11 THE TEACHER'S GUIDE

The contents should be structured in the following way:

1. Module title and number

2. Type of module

3. An introduction to the teacher which should include a validation of the topic, an overview of the whole module, and the more general aims and objectives

4. A content sequence and alternative routes and pathways through the module

5. An estimated time required for the section

6. Materials supplied for the module, (this should include transparency masters and relevant data tables)

7. Specified expected learning outcomes or competencies

8. A detailed statement of ther micro-scale aims and objectives

9. Module materials - content

10. Experiment cards - including apparatus lists and diagrams

11. Worksheets and solutions

12. A pool of objective type questions

13. Useful references and addresses

14. Extension work and experiments.

7.12 THE PUPIL'S BOOK.

The pupil's book for each module should contain :

1. The title and module number

2. The type of module

3. A validation of the topic

4. A clear statement of the expected learning outcomes

5. The content and context

6. Experimental details

7. Worksheets

8. Enrichment material

9. Extension and enrichment work and experiments.

10. Restatement of the expected learning objectives.

It is important that these books should be well and copiously illustrated and simply written. The structure of the student materials should relate to the module description - academic or applied. Each pupil's book should CONTAIN a clear statement of the learning objectives at the beginning and at the end.

8 A CAUTIONARY STATEMENT WITH REGARD TO THE VALIDATION AND APPROVAL OF MODULES.

In Physical Science, with 18 modules proposed for the Standard 10 School Leaving Certificate (see section 12.1), no more than 26 to 28 modules should be on an approved list. As experience and circumstances determine, one or more of these modules could then be replaced or revised as and when required. If publication of module materials were contracted out to a commercial publishing company, a portion of the royalty payments could be invested in a trust fund to finance revisions and the compilation of new modules. A national symposium of key persons in the field of science education should be called where recommendations regarding the principal themes of modules could be formulated.

Without a central 'directorate' to co-ordinate the development of what should become an 'approved' module list a 'TOWER OF BABEL' situation could arise where several different education departments develop their own themes. An uncontrolled growth and proliferation of modular units would be an enormous waste and duplication of limited manpower resources - and would lead to confusion at the certification level. It must therefore be considered whether one education department would be a generally accepted base to develop modules for their own use and for use by other departments. Would it not perhaps be more efficient if the development of modules was managed and co-ordinated by an independent body for use by the education departments that opted into a modular system? Modules prepared in either way would of necessity, have to be submitted to the National Certification Council for approval.

9 ADMISSION TO TRIALS IN MODULAR EDUCATION AND AN EXPERIMENTAL STRUCTURE.

If a modular system is to be introduced it would be impractical to enter into large scale trials. Pilot schemes would be essential but run on a fairly modest scale. Added to this limitation, entering into long term trials would necessitate extensive negotiations with various authorities - not the least of whom would be the National Certification Council. It is predictable, with a high degree of certainty, that no certification in a form other than the traditional matriculation or school leaving certificate would be acceptable to pupils and parents. Thus considerable concessions would have to be requested for certification in the pilot schools. Perhaps the maximum size for trials of this nature would be no more than a sample of five or six schools with no more than a total of 250 - 300 pupils in Standard 9 in the first year of the trials.

No trials should be considered in any school year until the full year's teaching materials and booklets are completed, published and available. Any lack of resources or delayed supplies, once the trial had begun, would serve to invalidate the whole experiment.

It would seem to be artificial to trial one or two modules only in one particular school. The cumulative effects as well as assessment of the individual materials should be the principal requirement.

The pilot scheme should expand by schools applying to join it - not by dictation and instruction. These applications should be accompanied by a commitment to the requisite in-service training. (see Section 19 re implementation)

10 MANAGEMENT AND ADMINISTRATION OF MODULAR SCIENCE

In an ideal situation, on the completion of each module's teaching and practical programme, a class list should be submitted to the regional office of education containing the basic data concerning the pupil and for the module concerned - marks based on an internal assessment, (e.g. a test and a more general work and practical assessment) should be submitted. This would entail a monthly external objective format examination. (To specify the details of this assessment at this stage of development would be premature in view of discrepancies in equipment and facilities between schools and the number of education departments likely to participate in any trials.) The final module assessment should be based on 25 % school contribution and 75 % from the final external assessment. Accepting the fact that internal assessment and contributory marks from the school is a contentious issue it is still valid to suggest that if teaching is a profession then professionals should contribute to the final assessment of their work. It would be a comparatively simple matter of statistical programming to run correlation coefficients and do scaling exercises if there were significant discrepancies between the internal and external assessments. (This refers to the proposed ACCREDITED TEACHER grading referred to in paragraph 14.1.)

In a more practicable and manageable situation fundamental modules (3 to 5 months work) could be examined as a block. Thereafter half yearly multimodule examinations or termly or 3 monthly examinations would decrease the administrative burden.

Certainly - in the trial stages - individual module tests for immediate feedback and revision for each module would be necessary.

11 ASSESSMENT CREDITS AND MODULE RECEIPTS

There are a number of options open for decisions with regard to final and/or intermediate assessment of modular Physical Science.

1. Final assessment of all fundamental and non-fundamental modules (Mode I or Mode II) at the end of the two year Physical Science Course. This would be comparable to the present departmental assessment methods.

2. Final assessment encompassing only the last year of the two year course. This would bring Physical Science into line with some other subjects.

(Neither of these two options would offer any solution to the interrupted schooling problem. These assessment processes would not permit the flexibility envisaged for the modular concept.)

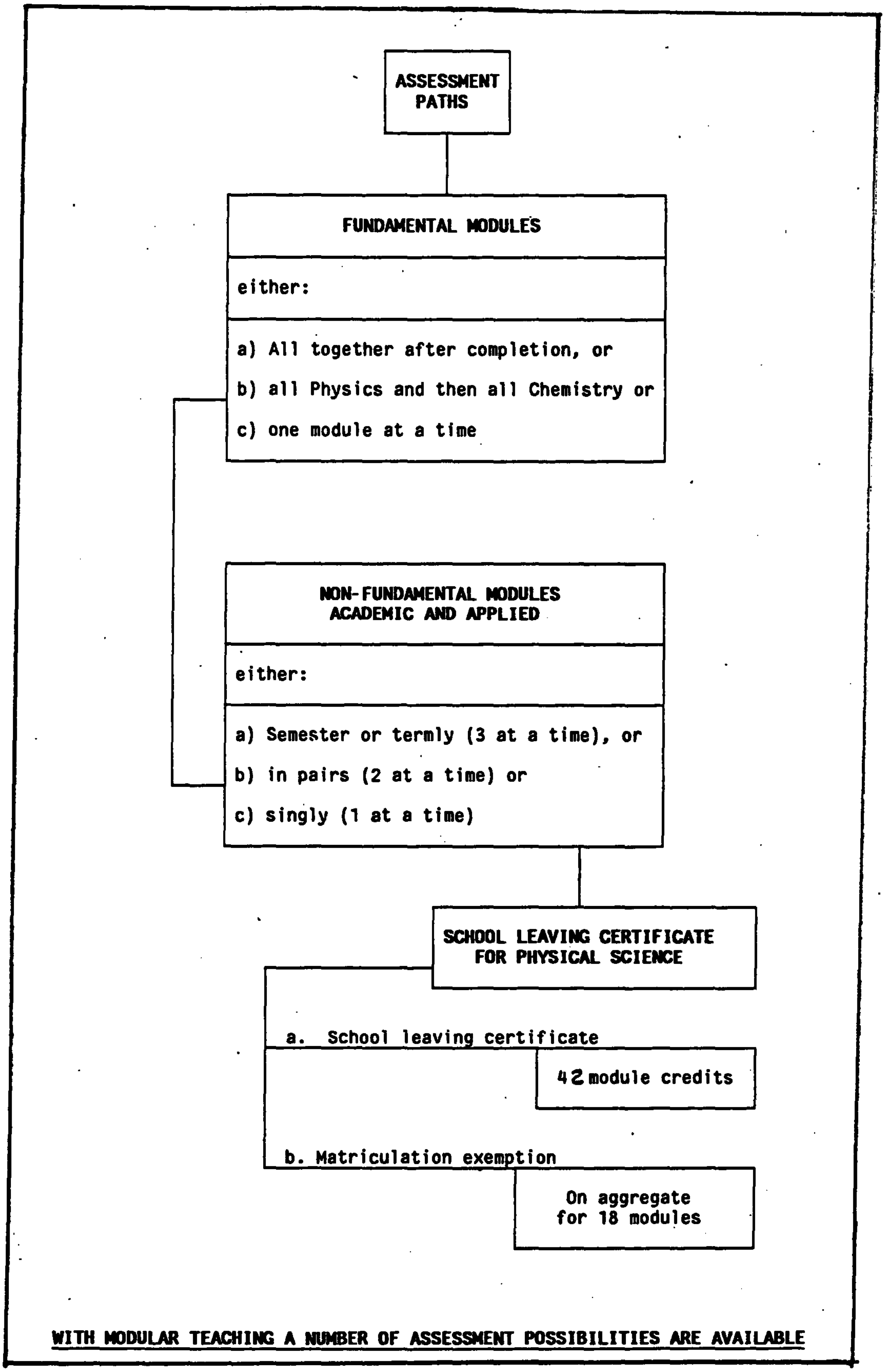
3. Assessment of the fundamental modules, when they are completed, as a 'single' block of work. These modules, examined as a group, could also be judged on a pass/fail basis as a qualification for entry to the non-fundamental portion of the two year syllabus. The non-fundamental modules would then present three alternatives for assessment :

i. An external assessment on a semester (or termly basis) i.e. approximately three months work in Mode I or Mode II or,

ii. an assessment of two modules (approximately two months work) at a time (in Mode I or Mode II) or, the most advantageous approach,

iii. an assessment of each module (approximately one month of work) (in Mode I or Mode II) as it is completed.

Table 5 : ASSESSMENT ALTERNATIVES



The prospect would then be held open for future consideration of a Mode III assessment of modules either for specific schools or identified teachers.
(see Section 5.1.1 for a brief explanation of the modes of assessment)

This last option has foreseeable drawbacks in that it represents a considerable administrative burden. However, it is seen as the most effective method and if the administrative system were to expand simultaneously with the growth of modular science in schools it would become no more than an extended spread-sheet exercise for a personal computer. Particularly in the early stages of school trials and testing of modules - rapid feedback from teachers, pupils and from 'computer marked' item bank type tests would be of considerable assistance to the authors and teachers. It is not envisaged that modular Physical Science should ever expand to schools outside of the original trial schools at an explosive or unmanageable rate.

In this proposal, after completion of a module or otherwise determined combination of modules - (this would in the best case be approximately 4 weeks' teaching time or perhaps a longer period for the fundamental modules) - schools would apply for departmental examination papers for that particular module. Each pupil, on completing the assessment examination, should be provided, through the departmental administration, with a receipt recording the name of the section, the 'credit' value of that section, and the aggregate mark of the combined internal and external assessments.

It is envisaged that there should be NO obligatory repeat in a particular module where a 'fail' mark was awarded - i.e. a receipt should be issued for every module examined. Exceptions could be made to this single module examination system so that it was not applied in cases of prolonged absence. The receipt should be issued irrespective of achievement level. The receipt should indicate assessed performance. A school leaving certificate would be awarded for the accumulation of a specified number of credits (see above) and a combined aggregate mark symbol could then be derived. A matriculation exemption would be awarded on a combined aggregate for all the modules completed by the individual pupils. This final grading symbol would appear on the school leaving certificate.

12 PROPOSALS FOR PUPIL EVALUATION

12.1 THE DURATION OF A MODULE AND CREDITS

The length of a module should approximate to 4 teaching weeks or 20 school days which should approximate to 18 - 20 hours of instruction. As pointed out earlier (section 5.1.7) the SCOTVEC module is 40 hours but it is felt that this is too long in terms of in-service training requirements. Similarly if modules are too long there would be a concomitant loss of flexibility in the overall scheme. Prior to the actual writing of modules - this uniformity of length may appear artificial but this is a view that only experience in compilation and in school testing could clarify and resolve.

The credit value of each fundamental module should be 3 credits
The credit value of each non-fundamental module should be 2 credits.

Taking into account that less teaching time would be lost due to the traditional time consuming processes of cycle tests or monthly mark orders, mid-year and end of year examinations, then the following schedule would be possible:

A school leaving certificate should be granted on 42 credits.
for example -

	6 fundamental modules	=	18 credits	(24-28 weeks)
	12 non-fundamental modules	=	24 credits	(48 weeks)
	----		----	------
Total	18 modules	Total	42 credits	72-76 weeks

This approximates closely to the Standards 9 and 10 [80 week] matriculation course and would permit considerably more class contact time in the equivalent two years since the traditional midyear and end of year examinations would be eliminated.

12.2 A PRELIMINARY PROPOSAL FOR A FORMAT OF A FINAL RECEIPT FOR A PUPIL'S MODULAR PHYSICAL SCIENCE RECORD

University entrance or matriculation should be based on the overall aggregate (or average) for the 18 modules completed with a weighting bias built in to favour the academic modules. (This proposal suggests 100 marks for an academic module and 80 marks for an applied module.) The reasoning here is that there should be no distinction between the various types of module for a Standard 10 School Leaving Certificate but that university and technikon entrance qualification and matriculation exemption is a separate assessment process and would have to consider the possible aggregate range which would be from 1400 (for a course of only applied modules) to 1800 (for a course of all academic modules).

This would also enable a pupil who had been taught a composite course of academic and applied modules in a mixed ability class to achieve a university entrance without any handicap. Table 6, on the next page shows a suggested lay-out for a final Physical Science receipt.

Table 6 : A PRELIMINARY PROPOSAL FOR A FORMAT OF A FINAL RECEIPT FOR A PUPIL'S MODULAR PHYSICAL SCIENCE RECORD -

MODULE TITLE	CREDIT VALUE	MARKS	
1. PHYSICS /FUNDAMENTAL	3	55/100	
2. PHYSICS/ "	3	68/100	
3. PHYSICS/ "	3	56/100	
4. CHEMISTRY/ "	3	72/100	
5. CHEMISTRY/ "	3	44/100	
6. CHEMISTRY/ "	3	53/100	
7. PHYSICS/ACADEMIC	2	66/100	
8. PHYSICS/ "	2	58/100	
9. PHYSICS/ "	2	57/100	
10. PHYSICS/APPLIED	2	56/80	#
11. CHEMISTRY/ACADEMIC	2	49/100	
12. CHEMISTRY/ "	2	54/100	
13. CHEMISTRY/APPLIED	2	58/80	#
14. CHEMISTRY/ "	2	54/80	#
15. CHEMISTRY/ "	2	59/80	#
16. CHEMISTRY/ "	2	45/80	#
17. PHYSICS/ACADEMIC	2	61/100	
18. PHYSICS/APPLIED	2	64/80	#
TOTAL	42	ACTUAL AGGREGATE 1029	
		POSSIBLE AGGREGATE 1680	
		Percentage % 61.3	

[# indicates an APPLIED module]

The entry on the school leaving certificate, for matriculation considerations, this would appear as -

---

Physical Science C
(modular)

On this school leaving certificate the pupil has a fairly good pass. On the Physical Science RECEIPT there are the details of the course followed and itemized achievements for the information of university/technikon admissions or employers.

13 A PILOT SCHEME FOR MODULAR PHYSICAL SCIENCE.

13.1 THE ADVANTAGES OF MODULAR INSTRUCTION IN PHYSICAL SCIENCE

The list of factors favouring a scientific and carefully conducted evaluation of a modular science course in a limited number of trial schools is quite extensive. Many of these factors are worthy of deeper examination. These would include -

13.2 EDUCATIONAL ADVANTAGES

HIGHER GRADE AND STANDARD GRADE UNIFICATION. Current and past science curricula have been criticised for being 'too academic' and for 'not being relevant' to the pupils. This criticism is even more true of the standard grade curricula. In the very best perspective - standard grade courses are too derivative from higher grade courses. Few, if any, standard grade pupils have a need for an in-depth academic approach to science. With a modular science certificate as proposed in section 12.2, the problems of university entrance can be solved with the detailed statement of the course provided in the module receipts. The needs of standard grade pupils and perhaps even a high percentage of higher grade pupils is for science relevant to the world they live in.

There is an almost total lack of awareness and knowledge of the scientific 'ecology' of this country amongst school leavers. The problems of the 'watered down' higher grade for standard grade approach is compounded by the fact that, whatever the intentions of schools are, H.G. and S.G. pupils are, more often than not, taught in mixed classes. Modular science, with a suitable selection of academic and non-academic modules could be directed specifically at mixed ability and different vocational groups with greatly reduced conflicts of interest.. (See above - module forms and definitions in Section 7)

13.2.1 A variable range of subject credits for a school leaving certificate .

A modular system assessed on a 'credit' basis for each completed module would add considerable variety and flexibility to the present school leaving certificate/matriculation system. 'Credit' assessment would allow consideration to be given to -

(i) the possibility, in the future, of more 'modular subjects with fewer than 6 subjects required for a matriculation exemption but with more credits per subject. Modular Science or Mathematics could be taken for example at a one and a half or double subject level with a requirement of 60 to 80 credits in Mathematics or Physical Science for the specialists and gifted pupils and only five different subjects.

(ii) a 'needs' designed school leaving certificate - in that Physical Science and perhaps, in the future other modularized subjects could be based upon the broad requirements of tertiary education specifications, e.g. highly competitive faculties could be expected to indicate, in broad outline, some of their modular preferences.

This need not necessarily be in conflict with the present system of subject groupings and requirements but if more subjects were modularized some modifications may become necessary. This would be a consideration for the National Certification Council.

13.2.2 Modules offer a quick response system to pressures for change .

Educationalists, politicians and business leaders in many countries, including South Africa, have called time and time again for flexibility and rapid responses to educational demands from curriculum planners.

> "It is essential that the education system not only be RESPONSIVE to changes, but that it responds RAPIDLY." (M. Sanders, S.A.J.Educ., 1986, 6(1), p. 64.)

In South Africa, the response time for curriculum change is in the order of 10 years or longer in some cases. This response time is far too slow for our rapidly changing economy and social and academic milieu. A modular system would have the advantage that the individual modules could be kept more or less continuously in a state of assessment and revision by schools, colleges and departments. Since, by definition, a module is a semi-independent teaching unit, individual modules could be revised, rewritten or even replaced without the concomitant ripple effect that occurs in other sections of the syllabus when any part of the present 2 year curriculum is adjusted. One module would have very little, if any, effect on the content of the others. New modules for newly identified needs and areas could be generated and tested in trial schools within a year of the need being established. In this way Physical Science curricula, at the individual module level, could be in a state of continuous redesign and revision i.e. the greatly desired, rapid response in our educational system. In a worst case situation - a rapid response that was, in hindsight, educationally less successful, would be open to immediate revision or removal from a list of approved modules.

PROPOSAL - The National Certification Council approve a list of fundamental modules and non-fundamental modules (say 26 - 28) which should be open to revision and/or expansion. From this list, the various education departments would have to make a selection for use in their executive areas. This would cater to the already expressed desires for individual group educational systems. The departments in conjunction with the National Certification Council should have the powers to determine whether a module should be fundamental or non-fundamental. Thus if any particular department wished to expand the compulsory portion of the Physical Science syllabus it should be able to do so.

13.2.3 Modular handbooks could be an economy measure .

A modular system based upon teachers' resource materials and module booklets for the students could be more economical than the conventional hard cover 300/400 page text particularly as no single school need hold more than the fundamental modules and preselected half year's module requirements. If absolutely necessary, after completion, a set of pupils' module materials could be redistributed to the next school expecting to use them. Soft covered thin manuals would have a reasonable life expectancy and be far less liable to damage and cheaper to replace than a conventional text. In addition, there would be no extended hiatus between the introduction of any new curriculum and the approval and publication of new textbooks as there is at present.

It must be noted that many of these advantages could be obtained from other curriculum patterns and administrative systems but it is possible that a modular system offers cumulative benefits that may not be possible in any other curriculum proposal.

13.3 SOCIAL AND SOCIO-POLITICAL ADVANTAGES

13.3.1 Modular instruction as an insurance against interrupted schooling .

For the last 3 - 4 years, in the black community, education has been interrupted by political action and boycott. With the present system, a pupil losing school time either looses all that years' work, in the case of Standard 9, or gets no attempt at a school leaving certificate if in Standard 10. Alternatively the candidates write examinations on what could be as little as 60 % of the normal teaching time (according to the media). The remaining teaching time will have been lost. A modular system would minimize the present catastrophic effects of interrupted schooling. (There is no reason to suppose that other South African education departments will be indefinitely exempt from this form of action and schools could quite possibly be subject to interruptions more often in the future.) Even the Scottish educational system, which historically has been relatively free of industrial action has, in 1986, been extensively hit by strike action and withdrawal of services by teachers. Modular instruction would provide at least some built-in protection for the pupils against interrupted schooling.

13.3.2 Modular instruction could bridge the gap for school transferees .

Pupils who move from school to school - particularly from province to province - face some hazard of missing key components of the present spiral curriculum. Often this is lost ground that cannot be made up. In a modular system the worst that can happen is that a pupil loses one module and continues in the new school with the next 'unit'. A single missing module would be a reasonable 'catch-up' target to set a pupil for extra-mural work. A similar 'catch-up' situation would exist for transferees who find that they have already done a particular module.

13.3.3 Modular credits could be carried into post-school education .

Late career decision makers, who may leave school without entry qualifications for any form of tertiary education could, on a 'credit' system, continue to accumulate credits at a later stage - after the end of their formal schooling. This could be achieved privately or through the technical college and technikon systems. Similarly, early school leavers who change their minds and academic aspirations are no longer cut off from self-improvement and advancement through the formal educational system. Slow learners could also have extended time to accumulate the 42 credits without outright failure or the necessity of having to repeat a whole school year.

13.3.4 The benefits to immigrants .

Invariably the children of immigrant families go through a protracted cultural and social disturbance and it is possible that a shorter term 'credit' assessment would improve their 'acculturation' in South Africa. This argument could also apply to the population which it is anticipated will move into the cities in the next few years with the abolition of influx control measures.

13.3.5 Modules for individual pupils who miss extended periods of school through illness .

In the comparatively few cases in which serious illness or accident has caused prolonged absence from school, a modular system would insure against a complete year of schooling being lost and reduce the burden on the pupil, when compared to the usual 'catch up' stress syndrome.

13.3.6 Modular instruction could take a variety of forms and be assessed in a variety of different ways .

Modular systems for Physical Science can take a number of forms. These would be largely determined by the overall assessment process adopted. (This has been discussed above in terms of intermediate assessents as opposed to a single final assessment.)

13.3.7 <u>A direct reward and recognition system for gifted pupils through the medium of accelerated learning and accelerated programming</u> .

A 'credit' assessed modular system would cater for high ability pupils in that the module unit time could be shortened and in accelerated learning conditions, either

(i) the requisite 42 credits could be accumulated in less than the 72-76 weeks described above, or

(ii) an excess of credits [e.g. 46 or 48] and an improved aggregate could be attained in the stipulated 72 - 76 weeks to optimize applications for 'high demand' tertiary education faculties.

This latter suggestion (ii) could be achieved in a number of different ways -

(i) through an accelerated programme in school,
(ii) through enrichment programmes, e.g. gifted centres and extra-mural provisions in the schools,
(iii) through vacation schools,
(iv) and through a 'magnet school' programme.

Enrichment could be provided through the medium of educational television, officially supported science clubs, "modular" video-tapes and educational radio programmes.

14 THE TEACHER IN A MODULAR SYSTEM.

14.1 MODULAR SYSTEMS OF 'IN-SERVICE' TRAINING COULD IMPROVE TEACHER SKILLS AND QUALIFICATIONS.

It is very necessary that any major curriculum innovation has facilities for teacher training and education as a built-in feature. Teachers are at present graded and paid according to their academic qualifications. In the main, promotions too are dependent on qualifications. Too little attention and credit appears to be given to skills and competencies other than annual increments in salary. Modular in-service training and achievement could form a new channel for recognizing teachers' skills and competencies.

It is generally acknowledged that the most serious problem with regard to science education in many departments is that of teacher qualifications, skills and experience. This situation is most serious in the Department of Education and Training. A modular system would facilitate a built-in teacher training and up-grading process which would directly benefit both the teachers and the schools they teach in. The normal in-service course, when it occurs, covers a wide spread of content which is, more often than not, out of synchronization with the actual teaching sequence current in the classroom at that time. A modular system designed to fit into the schools' teaching programme and with suitable incentives for attendance and achievement would increase the confidence and competence of class teachers. Teachers would be receiving training in modules immediately before their classroom need of this training.

TABLE 7 : INSERVICE TRAINING COMBINED WITH CLASSROOM TEACHING

A TEACHER'S TERM PROGRAMME FOR TEACHING AND IN-SERVICE TRAINING

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13
MORNINGS 07h30-13h30 Normal timetable	SCHOOL ADMINISTRATION	TEACH MODULE 1 e.g. - The nucleus			MODULE TEST	TEACH MODULE 2 e.g. - Electronic structures & bonding			MODULE TEST	TEACH MODULE 3 e.g. - Rate and equilibria			MODULE TEST
AFTERNOONS 14h30-16h30 In-service training	In-service Training for Module 1 e.g. the nucleus				In-service training for Module 2 e.g. electron structure and bonding				In-service training for Module 3 e.g. rate and equilibria				In-service training for Module 4 e.g. materials

± 9 hours training and competency assessment per module

Thus there would have to be a sequence of priorities for the teacher training aspects of modular Physical Science:

(i) <u>Teacher up-grading and orientation</u> Where every science teacher involved in a pilot modular system would have to be exposed, in a training course, to every module before it is used in the classroom.

(ii) <u>Teacher Training</u> As the modular system expands, the teacher training colleges would have to rearrange their programme to suit the needs of 'module' competent teacher graduates.

(iii) <u>In-service training</u> Those teachers already in the classroom would need exposure to modules and the modular system before becoming part of the pilot module scheme.

Such teacher training and upgrading could be beneficially expanded by compiling a series of modules directed towards upgrading teachers' skills. These modules could include essential supportive skills such as modules on:

(i) laboratory management
(ii) laboratory first aid
(iii) laboratory technical skills
(iv) class management
(v) practical class management and
(vi) report and practical writing skills.
(vii) assessment and evaluation

These enrichment modules in teaching skills added to curriculum modules would have the advantage that the teachers could perceive as having a direct benefit to their professional activities. Competence in these 'professional' modules added to curriculum module training should be acknowledged by the employing department in the form of 'college' credit and/or salary increments.

PROPOSAL Teachers who have been to a predetermined number of 'module' training courses and who have shown a sufficiently high level of competency (on post training tests) should be given some form of recognition of their achievement.

PROPOSAL Teachers who have a satisfactory attendance and achievement (say 80 % of module courses at an assessment level of 70 % on predetermined competencies) should gain academic credit. This credit should be either in the form of credit courses at teacher training colleges or as a salary scale increment.

PROPOSAL Identified teachers should be upgraded to the status of "ACCREDITED TEACHER' or a head of department position.

This would be determined by satisfactory performance in module training courses and overall academic standing. This would give two grades of head of department - those with curriculum responsibilities and those without such responsibilities. An ACCREDITED teacher would be able to make professional decisions about his/her subject in the classroom, i.e. select modules for the school curriculum, participate in an internal assessment scheme and run his/her own training courses. This would have the added advantage of identifying teaching as a profession with professional responsibilities.

The accumulation of academic, financial and status credit through inservice training and devolution of earned responsibilities would enhance the opportunities of a modular system succeeding in our high schools.

Where no 'accredited' teachers are available in a school or a circuit the decision making would have to rise to the next competent level in the regional management (see Section 15.1 below).

15. A NEGOTIABLE CURRICULUM

15.1 A 'NEGOTIABLE' MODULAR CURRICULUM WOULD ENABLE THE BEST USE TO BE MADE OF SCIENCE TEACHERS AVAILABLE IN ANY PARTICULAR SCHOOL

Another benefit of a modular system is that, where permitted or earned, schools would be able to take best advantage of 'in house' teachers skills and preferences. By judicious selection of modules teachers would become 'experts' in a particular field or group of modules. This would add to professional confidence and self-esteem and would benefit the school and the pupil. A modular system applied in this context would also be responsive to staff interests and skills. In larger schools where setting is possible two, or even three, different modules could be taught at the same time by different teachers with an enhanced variety of options available to the pupils. This would be a decision-making situation for the 'ACCREDITED' teacher.

15.2 THE CONCEPT OF A 'NEGOTIABLE' CURRICULUM

A modular curriculum opens up the possibility of a 'negotiable curriculum' in which - at some agreed level - someone in a particular school teaching science on a modular basis would make decisions about what will be taught in that school. This raises once again the concept of an 'ACCREDITED' teacher and the questions that accompany the concept. Sound modern business principles suggest that decision making should be reduced to as low a level in a hierarchy as is possible. If a Physical Science curriculum is 'menu driven' from a variety of modules on offer - would it not be beneficial to both the teachers and the subject if the decisions as to which modules were actually used was made in the school - at an 'ACCREDITED' teacher or head of department level?

15.3 A SCIENCE CURRICULUM DESIGNED AROUND PUPIL NEEDS

In this way the science taught to the generality of students would not be determined totally by 'academic' requirements and could be made relevant, to some extent, to the local environment and scientific activity. There is no dispute with the need for all academic candidates to have a common core of pre-academic tuition. However, for the large majority of students who have no desire or intention of proceeding into tertiary science training the present syllabi have no real meaning or value. The non-academic science experiences and needs of students in rural areas are not the same as the experience and needs of the residents of high density urban populations. It would be possible through the medium of modular instruction to provide Agricultural Science for the former and Electronics or Industrial Chemistry for the others. A student in the Cape would probably attach very little importance to a module on coal whereas it would be a valuable educational experience for a student living in Newcastle or Middelburg.

By offering different modules in sets, individual pupil choices could be made, e.g. a choice between an academic and an applied module which are being taught at the same time.

Instruction based on a modular system would mean that the timing of learning experiences could be adjusted to suit small groups and classes outside the formal classroom situation.

By a judicious mixing of academic and applied modules a teacher would be more able and equipped to deal with mixed ability classes.

It is demonstrable that the process of modularization would modify the current 'strict regime' curriculum and make the process of schooling more fitted to the needs of pupils, tertiary education and employers alike.

The common core of fundamental modules would ensure the coverage of 'educationally' requisite material and concepts but outside this core a modular system would cater, to some extent at least, for local needs, interests and concerns.

16 MODULAR INSTRUCTION PRESENTS A FLEXIBLE TEACHING SYSTEM

16.1 MODULES ARE A FLEXIBLE SYSTEM OF INSTRUCTION

An intrinsic part of a modular system is its flexibility with regard to content and sequencing of learning experiences. What is often overlooked and perhaps is equally significant, from the teachers point of view, is that a modular system opens up a whole variety of teaching methods and techniques. Certainly the advent of a modular 'relevant' science scheme into schools would make the prospect of considerable changes from the traditional 'didactic - chalk and talk' approach to a more fulfilling 'interactive' or 'open teaching' method possible. In these circumstances - where the state of the pupils' knowledge and opinions becomes a valid starting point for any module - teaching and learning science is more likely to become an interesting and attractive proposition for scholars.

16.2 PSYCHO-SOCIAL ADVANTAGES

A modular system which is to some extent 'pupil paced' has many clearly defined advantages to pupils. Slow learners would not face the two or more years of academic 'stern chase' and developing inferiority and frustration that they face at present. Each module would in effect be a new beginning for the slow learner.

A modular system would cater far better for the diverse expectations of the various groups of school leavers. In the United Kingdom this aspect of science education is satisfied by the numerous science examinations on offer at O-level and in the new General Certificate of Secondary Education (GCSE). At the present time there are numerous approved science syllabuses available for schools and pupils to select from in England and Wales. In South Africa there is only provision for one science subject at three levels. This restricted science offering cannot be equally meaningful and satisfactory for all the science pupils of the country. With the shortage of science teachers that has been identified - it would not appear possible or even desirable to offer a wider range of science subjects. Modular Science would provide some offering to counter the lack of variety in examinable courses.

Modular instruction coupled with individual module assessment would satisfy the concept of 'immediate reward'. Two years is a long perspective for the average school child. A teacher telling a pupil that the work done now will be important in a years' time is not motivating that pupil at all. That horizon is too far away. Regular assessment and feedback, in the form of 'receipts' would be a far greater motivation for progress. On the same basis - continuous assessment, which cannot be taken away, would considerably alleviate the 'examination season syndrome'.

16.3 'SPECIAL EDUCATION' PROVISIONS

The idea of intermediate courses constructed by mixing academic and applied modules would be beneficial to a majority of pupils who want a science education but have no intention of training further for a science based profession, i.e. modular Physical Science would accommodate the needs of a greater proportion of the school population without handicapping those pupils with science career ambitions.

The concept of interdisciplinary studies, mentioned earlier, is another important consideration. The three basic sciences [Chemistry, Biology and Physics], were divisions imposed on science over 150 years ago. The corpus of scientific knowledge has grown to such an extent that these distinctions are no longer tenable. The vastly increased number of fields of scientific endeavour make such divisions artificial. These traditional divisions of school science make no allowance for the newer fields of scientific endeavour nor do they allow consideration to be given to the technologies which are so much part of daily life. The trend towards Integrated Science for all pupils is the tendency in nearly all the European countries. This is a factor that should also be taken into account when considering the Standard 6, 7 and 8 curricula.

17 PROBLEMS ANTICIPATED FOR THE CONCEPT OF A NEGOTIABLE CURRICULUM

With whom or at what level will the negotiation take place? In a pupil centred educational system the obvious level is at the individual pupil level. However, this has many drawbacks on an emotive as well as an academic level. How competent is the pupil to make options? A class democratic selection would have the potential of leading to a form of anarchy in the curriculum. Pupil selection from a 'menu' on offer (i.e. two or more teachers set together but each teaching a different module at the same time) would present administrative problems - particularly in situations where the teachers' personalities become more important than the subject. A negotiable curriculum at the teacher level with an accredited head of department guidance and veto or final say may be the best solution but with a proviso that the teacher concerned has been given some form of 'official' means and quality assessment. A negotiable curriculum at the head of department level would also have many advantages - one of which would be that this responsibility could become a valued form of professional recognition and an opportunity for local teachers to take cognizance of local needs, interests and activities.

If a negotiated curriculum is decided upon further up the administrative chain of command many of the advantages of this negotiable curriculum will have been lost. Decentralization of the decision making process is one of the established policies of the Government and curriculum decisions, like decision making in large corporations, should be taken at as low a level as possible. Why not take the advice of a head of department if s/he has earned an 'accredited' status?

Centralized curriculum development and dissemination has not been effective as can be seen in the Nuffield and PSSC projects in the UK and the USA respectively. The philosophical core becomes distorted to suit local and individual teacher needs and personalities. The theories on curriculum development and dissemination will be dealt with in more detail in a later report.

18 COUNTER INDICATIONS

There will be a predictable tendency, particularly amongst poorly trained teachers and for teachers with few or no resources, for non-systematic science to be taught. They will almost certainly lack any formal subject discipline and have no wider perceptions of scientific endeavour and will consequently need careful in-service training. This drawback will be felt even more strongly by those teachers who cannot, for reasons of distance, or will not attend in-service training courses. This observation is unanswerable save for the fact that no matter what efforts are made to equalize education it remains a human endeavour and humans are intrinsically different. Therefore schools will be different in that their staffing will differ, and their priorities will differ also. However, well designed teacher's handbooks and pupil booklets or 'combination' books should serve to alleviate some of these problems.

Teachers will lose sight of the overall subject image and structure. The pupils may never get it. This is again particularly true for poorly trained and qualified teachers. The effect here is answered partially, at least, by reintroducing the concept of accredited teacher grading and limiting the modular innovation to these teachers and those teachers whom they are in a position to advise and guide directly. Other science teachers, who are not eligible, or who do not choose to change over to a modular scheme, would continue to teach according to the existing system and for external final assessment. Thus there would be two parallel science education examination and certification systems in operation for the foreseeable future - the modular and the traditional linear syllabus.

Materials, e.g. books and equipment may be more costly, but at least they could to some extent be locally produced. This would be eminently applicable if the KENYAN system were examined more closely and implemented. In Kenya there is a locally financed apparatus design, test, manufacture and marketing organization operated by the Ministry of Education. Science education students are expected to spend part of their training there - both constructing equipment for sale to schools and also gaining practical experience in laboratory and workshop management.

What amounts to monthly external examinations presents a considerable security problem in keeping examination papers confidential. The mailing, storage and administering of these examinations presents an appreciable risk to which there are no obvious solutions save that it would only be the schools with 'accredited' teachers and their staff involved in this system. Professional responsibilities and the handling thereof, remains an enigma.

Administrative support also presents appreciable problems. The keeping of individual records would add a new layer of work to an already complex educational system. However, there is nothing in the proposals outlined above that could not be adequately controlled by a computer based spread sheet system, but cost, time and operators may represent a difficult problem to solve, particularly if a modular system expanded to an appreciable number of schools.

The innate and natural conservatism of education toward major changes must be taken into consideration. The universities too, may view such a change as an attempt to determine an admissions qualification policy, and could become a major problem unless adequate preparations are made. Certainly this is becoming a factor in the UK educational system. The directives from the Department of Education and Science promoting Integrated Sciences and the new General Certificate of Secondary Education has already been foreseen as the removal of some of the discretion from the universities over admissions and required subjects for entry into science courses.

19 IMPLEMENTATION PRACTICALITIES

ANY PLAN OR OPTION WILL HAVE TO BE NEGOTIATED BETWEEN THE DEPARTMENTS AND THE NATIONAL CERTIFICATION BOARD. THERE IS LIKELY TO BE A CONSIDERABLE ADMINISTRATIVE HURDLE IN SETTING UP EVEN A LIMITED NUMBER OF PILOT SCHOOLS FOR A MODULAR PROJECT.

It would be irresponsible if an independent assessment and evaluation process were not set up and operate parallel to the field testing. Similarly an item bank of module questions would have to be established for use with each module well ahead of time. Pre-trials and 'in situ' independent evaluation would appear to be a prerequisite feature of any pilot scheme.

The selection of schools and classes would have to receive careful consideration by the departments concerned. One possibility would be to select some classes within a school for a modular experiment and other classes in the same school to proceed with normal instruction. By having parallel classes, modular and non-modular, a situation with a built-in experiment with an informal control would develop. This option could be open to the misinterpretation that is discriminatory against one group or the other. Many politicians could exploit this possibility to the disadvantage of the overall idea without some careful public relations work ahead of the trials.

Another option would be for a whole year group in selected schools to be entrained into the experiment.

A third possibility is the establishment of a magnet school in which experiments in modular science are carried out. Any diffusion of the idea would then take place through the 'feeder' schools to the magnet school.

The design of the experiment and liason between the various education departments and any other organization involved would require definition and approval at a high administrative level in the participating departments.

Decisions would have to be made with respect to costs, funding and fund raising operations in what would become a joint inter-departmental venture.

The implications of parallel teaching systems would also have to be examined very closely if the first option, mentioned above, is selected for the pilot scheme.

20 THE CONTROL OF TRIAL SCHOOLS

A modular Physical Science scheme should be developed and used in a limited number of pilot schools.

Suitable liason channels should be established between interested education departments and any other organizations involved to manage functions such as funding, day to day management, assessment evaluations and administrative decisions as they become necessary.

Co-operation with regards to private sector fund raising will be necessary.

A critical factor in compilation of modules would be approval of the proposed format by all participating education departments.

In short, a joint management group would have to be established to manage the whole project and to control its operation and growth.

21 THE PRIVATE SECTOR CONTRIBUTION

One of the key recommendations of the Human Sciences Research Council's Investigation into Education (1981) was the need and the necessity for the involvement of the private sector in education and in the provision of education. The sponsorship of the commissioning fees for individual modules would appear to fit the HSRC's recommendations perfectly. By underwriting the costs of a single module and acting as an information and resource base the interaction of schools and industry would be brought into effective practice at no great cost to any single commercial organization. Only an approximation of the costs of writing a single module could be made at this early stage. This would have to be determined fairly accurately, inclusive of the costs of a trial publication, if this proposal is proceeded with.

The logical development of this step would be to contract publication of modular texts and divide royalties and establish a fund to commission reviews and rewrites and new materials. In this way curriculum materials would become self generating insofar as finance was concerned.

22 CENTRALIZED AND DECENTRALIZED CURRICULUM DEVELOPMENT.

As pointed out by Eden and Tamir (1979), teacher and community participation in curriculum development is not as easily obtained in a centralized education system. Similarly with the acceptance that common norms and standards for matriculation throughout South Africa are of over-riding importance an extensively decentralized educational system is not possible. Through a modular system of Physical Science education a rational course between centralization and the benefits of decentralization can be found. On the same basis, present curriculum changes are introduced universally within a department's schools - there is often no research and development model or formal trials before these changes are implemented. Small scale trials and limited participation in the rewriting of a curriculum presents a manageable option. In this proposal, trials and controlled admission to the scheme would be of the essence. No school would be in a position where its participation in a modular scheme would be dictated to it. Parallel systems, modular and the conventional two year course with a terminal examination, would obviate the need for the element of 'rational persuasion' that Eden and Tamir (1985) have doubts about. Of added value in the assessment of such a modular course would be a careful monitoring of the rate at which applications are received from schools that wish to associate with it.

23 CONCLUSION

This proposal for modular Physical Science is compatible with the recommendations of the HSRC Investigation into Education (1981), it is compatible with the growing world trend towards teacher participation in curriculum development and it could offer theoretical guidelines for the modularization of other traditional school subjects.

The early part of this report built up a convincing need for the re-examination of Physical Science as it is taught in the high schools of the RSA and that any new system must be take a trials and pilot scheme process before a more general implementation. Modular Physical Science provides a logical, and it is hoped, a cohesive approach to the need for curriculum flexibility.

Any effort to activate this programme would need the active co-operation of:

* the National Certification Council,
* one or more of the Education Departments,
* writing groups of teachers and other educationalists,
* Industry and Commerce, both for financial and other assistance and
* a determination by all parties concerned that a modular exercise should be a joint co-operative exercise and not an antagonistic or competitive one.

The main aim of this study is to start an open discussion on the whole concept of modular curricula in South African schools which will hopefully lead to a national Forum on this issue.

A SELECTED BIBLIOGRAPHY

ACKERMAN, H. The President's Column. Transvaal Educational News LXXXVI (10), November/December 1985.

ADLER, M. The Paideia Proposal. New York : McMillan, 1982.

BIOLOGICAL SCIENCES STUDY COMMITTEE. Biology - A molecular approach. San Francisco : Freeman, 1963.

BLACK, P. Integrated or co-ordinated science? School Science Review 67(241) 1986 : 669-681.

CENTRAL STATISTICAL SERVICE. Education - Indians 1984. Report No. 21-04-18, 1984.

CENTRAL STATISTICAL SERVICE. Education - Coloureds 1984. Report No. 21-03-18, 1984.

CENTRAL STATISTICAL SERVICE. Education - Whites 1984. Report No. 21-02-19, 1984.

CHEMICAL EDUCATION MATERIAL STUDY. Chemistry - an experimental science. San Francisco : Freeman, 1963.

CHOING SEW YOONG. Educational systems : Making Science, Technology and Mathematics education relevant to youth in developing countries. Science and Public Policy 13(3), June 1986 : 125-133.

COLLINS, D.J. Speech in Durban, 09-09-1987.

CURRY, A., HOLMAN, J. SATIS - Physics goes live. Physics Education 21(5), 1986 : 268-271.

DEPARTMENT OF EDUCATION AND TRAINING. Annual Report. Pretoria 1985.

DEPARTMENT OF EDUCATION AND SCIENCE. Criteria for Science education. DES in conjunction with the Open University. United Kingdom, 1985.

DIGEST WITH EDUCATION. Modular curriculum . Education (London) 168(23), 1986 : i-iv.

EDEN, S., TAMIR, P. Curriculum implementation - retrospect and prospect, curriculum implementation and it's relationship to curriculum development in science. Israel Science Teaching Centre, Hebrew University, Jerusalem, 1979.

EISNER, E. The educational imagination. New York : McMillan, 1979.

EAST ANGLIA EXAMINATIONS ASSOCIATION. Physical Science (modular). Norwich, 1985.

FEYERABEND, P. Against method. London : Verso, 1978.

FLINDERS, D.J., NODDINGS, N., THORNTON, S.J. The nul curriculum : its theoretical base and practical implications. Curriculum Inquiry 16(1), 1986.

GARBERS, J.G., et al. , Co-ordinated progress in the teaching of Mathematics, Physical Science and Biology - context, conditions and tasks. South African Journal of Education 6(1), 1986.

GARFORTH, F. British Council Course 629 lecture : The new GCSE System, July 1986.

GATHERER, W.A. (Lothian Chief Education Adviser), HSRC Seminar, March 1987.

GERRANS, G. Science Faculty lecture, University of the Witwatersrand, March 1987.

GRAY, D. An old humanist's reply to Apple. Curriculum Inquiry 15, 1985 : 319-323.

GRAY, D.J. Optional topics in South African Physical Science. York : University of York, 1986. (M.Sc. thesis)

HEARNE, J.D., COWELL, R.V. Curriculum development : A critique of philosophical differences. Education 108(1), 1988 : 53-56.

HECHT, K. Teaching natural sciences - an integrated approach. Physics Education 21(5) : 283-287.

HOFSTEIN, A. Life from the Dead Sea. Israel : Witzman Institute for Science Education, 1984.

HOLMAN, J.S. Resources or courses? Contrasting approaches to the introduction of industry and technology to the secondary curriculum. School Science Review , March 1978 : 423-438.

HOLMAN, J.S. Lecture. British Council Course 629, University of York, 1986.

HOUSTON, W.R. Competency based teacher education : Progress, problems and prospects, Chicago : Science Research Associates, 1972.

HUMAN SCIENCES RESEARCH COUNCIL. An Investigation into Education. Sub-reports 1, 6 and 12. Pretoria : Human Sciences Research Council, 1981.

JAMES, W. Essays in pragmatism. New York : Hafner, 1948.

JANSEN, C.P. Model vir 'n kurrikulumsentrum in die RSA. Pretoria, Universiteit van Pretoria, 1984. (D.Ed. - proefskrif)

JOINT MATRICULATION BOARD (JMB). Examinations handbook. Syllabuses implemented in 1986.

JOINT MATRICULATION BOARD. Extracts from annual report - 1985. Pretoria, 1986.

KERLINGER, F. The influence of research in education practice. Educational Researcher 6(8), 1973 : 5-12

KERLINGER. F, Foundations of Behavioural Research. New York, Holt, Reinhart and Winston, 1973.

KUHN, J.S. The structure of scientific revolutions . Chicago : University of Chicago Press, 1970.

LAING, M. The three new textbooks for Standard 9 Physical Science. Spectrum , 1987 : 252.

LAMP PROJECT MATERIALS (Less Academically Motivated Pupils). Association for Science Education (ASE) - A series of topics for slow learners. 1976.

NATIONAL ASSOCIATION OF SCIENCE TEACHERS ASSOCIATIONS (NASTA). Technological literacy and the science curriculum. Curriculum conference - New Jersey Supervisors Association. March 1985. ERIC Report 21801465, 1986 : 20-21.

NATIONAL SCIENCE EDUCATION FOUNDATION. A nation at risk. Washington, 1984.

NEW SOUTH WALES. Science syllabus - Years 11 and 12. Sidney : Board of School Studies, 1984.

NORTHERN EXAMINATIONS ASSOCIATION. Manchester, 1986.

Physics Syllabus A. (1986)
Chemistry. (1986)
Chemistry (Core). (1986)
Chemistry (Modules). (1986)
Salter's Chemistry. (1986)

NUFFIELD FOUNDATION - Chemistry, Physics, Biology, Combined Sciences, Advanced Science -Chemistry, Series. London : Penguin Books 1964 et seq .

ODENDAAL, M.S. Needs analysis of higher primary teaching in Kwa Zulu. Per Linguam . Special issue 1, 1985. Stellenbosch : University of Stellenbosch.

PIENAAR, L. The training of Artisans. Pretoria : Human Sciences Research Council, 1987.

PHYSICAL SCIENCES STUDY COMMITTEE. Physics. San Francisco: Freeman, 1963.

SALTERS CHEMISTRY PROJECT. University of York, 1986. Approved by the GCSE Council.

SANDERS, M. South African Journal of Education 6(1), 1986 : 64.

SCOTTISH EDUCATION DEPARTMENT. The structure of the curriculum, 1984.

SCOTVEC (Scottish Vocational and Educational Council). 1985.

SCRIVEN, M. Self referent research. Educational Researcher 9(6), 1980 : 11-16.

SECONDARY EXAMINATIONS COUNCIL National criteria for science education - Chemistry. Milton Keynes : Open University Press, 1986.

SOUTH AFRICAN ASSOCIATION FOR TEACHERS OF PHYSICAL SCIENCE. A science education policy for South Africa. Johannesburg, 1978.

TAMIR. P, Making the best use of matriculation examinations. Spectrum 26(1), 1988 : 2-4.

THE ASSOCIATED SCIENTIFIC AND TECHNICAL SOCIETIES OF SOUTH AFRICA. Kelvin News , November 1984.

THE SALTERS' CHEMISTRY PROJECT. An introduction with summaries of the course units . England, University of York 1986.

THOMPSON, Sir Harold. Educational technology in the teaching of Chemistry. Inaugural presidential speech. IUPAC, 1975.

TIMES EDUCATIONAL SUPPLEMENT. October 1986.

TITCOMBE, A.R. School Science Review June 1983 : 619

TOBER, K. University of the Witwatersrand. Inaugural address. Johannesburg, 1983.

TRANSVAAL EDUCATION DEPARTMENT. Syllabuses implemented in 1986.

TUTHILL, D., ASHTON, P. Improving educational research through the development of educational paradigms. Educational Researcher 12(10), December 1983.

ZOLLER, U. Relevance is primary in secondary Chemistry. Science Teacher 52(9), December 1985 : 32-35.

SCOTTISH VOCATIONAL EDUCATION COUNCIL

22 Great King Street, Edinburgh EH3 6QH
Tel: 031-557 4555

38 Queen Street, Glasgow G1 3DY
Tel: 041-248 7900

NATIONAL CERTIFICATE MODULE DESCRIPTOR

Ref No	Catalogue Number — Session 1986-87
Title	Title as in the Catalogue
Type and Purpose	Indicates the type of module, eg half, full, double - general or specialist and a brief statement indicating the broad aims of the module and the probable target audience
Preferred Entry Level	Gives an indication of the previous achievement likely to be required. Not prescriptive but to be recommended
Learning Outcomes	A learning outcome is one element of a student's achievement resulting from the completion of a given module. In most modules there will be no more than 5 or 6 learning outcomes. Learning outcomes embrace: Knowledge: know and use the key ideas, principles, language structure, processes, etc Skills: communicate clearly, plan, design, solve problems, manipulate data, order ideas; diagnose, rectify, assemble, dismantle, manipulate a keyboard, align, measure, etc Behaviours: work safely, hygienically, co-operatively, diligently, etc NB Learning outcomes cannot be altered in any way Learning outcomes need not necessarily be taught in the sequence in which they appear
Content/ Context	The content/context allows the tutor to structure student activities which suit the student's needs, staff expertise and the availability of resources. However, Centres must ensure that the content and learning approaches adopted allow students to meet the learning outcomes and agreed assessment procedures. The content section of module descriptors is for guidance only and may be amended or replaced by the Centre without approval by the Council. Although the content of a module may still be important, there are many cases where it is merely the vehicle for the development of practical skills, and does not provide the main focus in the development of learning approaches. It is important for the learner to be offered time for reflection and an opportunity to learn from experience. Overloading of modules should therefore be avoided in order to provide time for review of progress, reinforcement and remediation and for the evaluation of the provision for different students.

Suggested Learning and Teaching Approaches	Appropriate to achieving the learning outcomes, selected from among the following: Working alone Working in pairs Working in groups Group discussion Debates Exposition Demonstration Team teaching Visitors Surveys Questionnaires Interviews Practical work Case studies Projects Assignments Simulations Individualised learning Computer assisted learning Programmed learning Work experience Residential experience Field studies Visits etc Tutors should seek opportunties for: promoting learning through activities by students using a problem solving approach to learning enabling students to apply skills in different contexts The emphasis should be placed on the participation of the learners in the learning process and on the use of a variety of resources and teaching approaches.
Assessment Procedures	Appropriate to the learning outcomes and the selected learning approaches - and indicating what are considered to be satisfactory performances for each learning outcome: Objective tests Short Answer Finished products Essays Log book Self-profiles Questionnaires Orals Folios Observation of performance in: Practical, case studies, projects Reports (oral, written or graphic) resulting from: Practical, case studies, etc NB 1 Assessment procedures in the descriptors are MANDATORY unless prior approval has been given by SCOTVEC for alternative procedures. 2 To qualify for the module, the student must satisfy all the assessment requirements. 3 Details of alternative assessment procedures and associated performance criteria should be submitted separately and approval received BEFORE the module is offered. 4 The intention to offer alternative assessment procedures must be indicated on Form NC2.
Exemplars and Guidelines	Only included in some module descriptors Gives examples of test material, case studies, projects, sources of information, etc.

Doc No 181917
Copy No 182603

R13,00